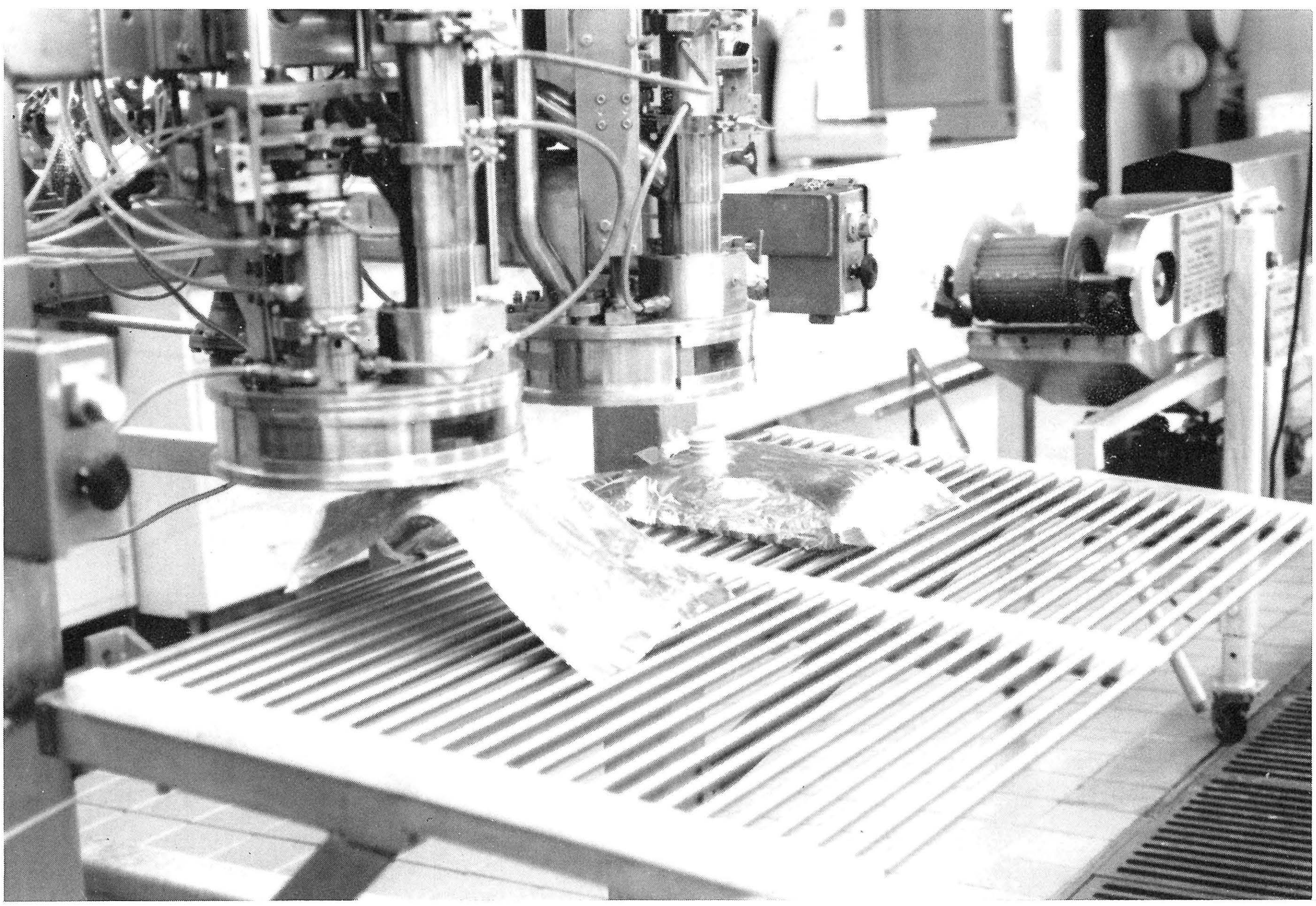
RESEARCH CIRCULAR 282 AUGUST 1984

Food Processing and Technology 1984: A Summary of Research



The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

CONTENTS

*** ** ***

ON THE COVER: Flexible film aseptic packaging machine.

AGDEX 410/71, 161/63-65-74-78, 257/35-70-73-76-81 8/84-2.5M

Textural Properties of Ohio Curd

H. M. WU and A. C. PENG[1]

INTRODUCTION

Ohio curd was developed in our laboratory by coagulating cheese whey and soymilk with glucono-delta-lactone (10). The product was a white, soft, gelatinous mass with an acceptable aroma and texture, high yield and protein content. The addition of cheese whey protein to soymilk enriched the essential amino acid content of soybean protein to upgrade its quality. This research was undertaken to investigate the textural parameters of this product.

MATERIALS AND METHODS

Materials

Soybeans of the Vickery cultivar were obtained from the Manchester Farm, Auglaize, Ohio. Sodium Protolac, a cheese whey protein concentrate (WPC), was provided by the Industrial Food Products, Borden, Inc., Columbus, Ohio; and Glucono-delta-lactone (GDL) was purchased from Sigma Chemical Co., St. Louis, Mo.

Ohio Curd Preparation

After being washed and soaked overnight under refrigeration, the soybeans were blended with fresh tap water (pH 7.0) at water:bean ratios of 6:1, 8:1, and 10:1 (v/w) for 5 minutes in a Waring Blendor. The slurry was filtered; the filtrate was boiled for 15 minutes and then cooled to 20° C. Sodium Protolac at 3%, 4.5%, 5.25%, and 6% (w/v) levels was dispersed into the cooled soymilk; the mixture deaerated for 1-1.5 hours, followed by mixing with 0.6% powdered GDL (w/v). The mixture was heated in a water bath at 85° C for 25 minutes, cooled under a running cold tap water for 25 minutes to enhance the hardening of the gel, and then refrigerated.

Textural Properties

An Instron Universal Testing Machine, Table Model TMM, CTM cell, was used to determine textural properties of the curd. Samples were tested in beakers, 6.80 cm inside diameter, filled to a depth of 3.2 cm. The flat plate plunger was 3.90 cm in diameter.

Figure 1 illustrates the position of plunger and sample upon initiation of the downstroke of the plunger. During the descent of the plunger, the crosshead speed was set at 1.0 cm/minute, chart speed was 20.0 cm/minute, and full scale deflection was 2.0 kg. Plunger penetration length was stopped at 1.0 cm. The relaxation curve was obtained by continuing to record the decay of the force, after the plunger was stopped, until a certain period of time had elapsed. Samples were tested at 22.2° C -23.3° C.

Three parameters: stiffness, bioyield point, and firmness were determined in the descending test, and two additional parameters, relaxation and plasticity, were obtained in the relaxation test. These were defined as follows:

Stiffness: the slope of the straight line in the force-distance curve during downstroke, having dimensions of kg/cm.

Bioyield point: the force (kg) at the peak or plateau in the force-distance curve during downstroke.

Firmness: the maximum force (kg) in the force-distance curve during downstroke.

Relaxation: the slope of the first exponential line obtained from the relaxation curve by using the successive residual method (5).

Plasticity: estimate based on the relaxation curve at the time of 4.4 min.

Data were statistically analyzed at the 95% confidence interval.

RESULTS

Textural Properties of Ohio Curd

The data in Figure 2 show the typical force-distance curve of Ohio curds obtained from the Instron Universal Testing Machine during the descent of the plunger. The curve began with a straight line until a break point was reached. The force was still increasing with changes in the slopes and showed fluctuations as indicated by several peaks and dikes until the downstroke was ended.

The stress-relaxation curve was expressed by the decay of force against time (Fig. 3). At the beginning the

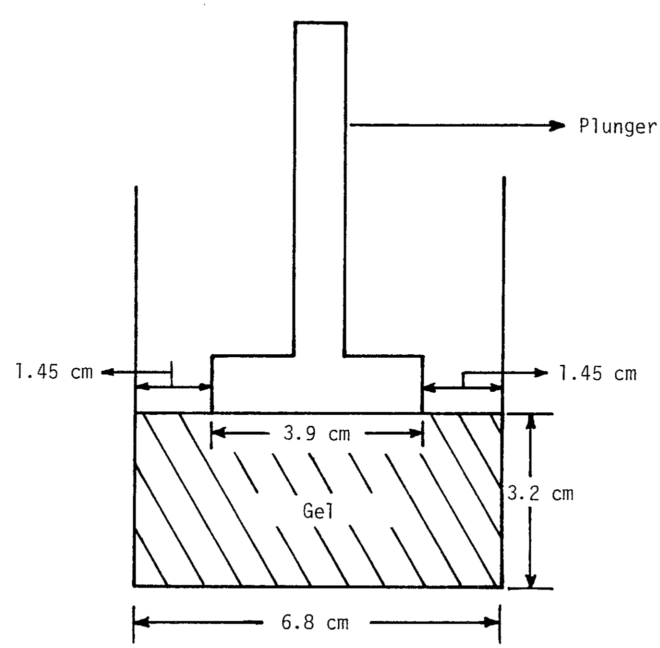


FIG. 1.—Diagram of the Instron test of the soy-WPC curd.

[1]Graduate Student and Professor, Dept. of Horticulture.

force dropped sharply, then leveled off. Three parameters, stiffness, firmness, and bioyield point, were obtained from the force-distance curve (Fig. 2). Relaxation and plasticity were the two parameters obtained from the relaxation curve (Fig. 3).

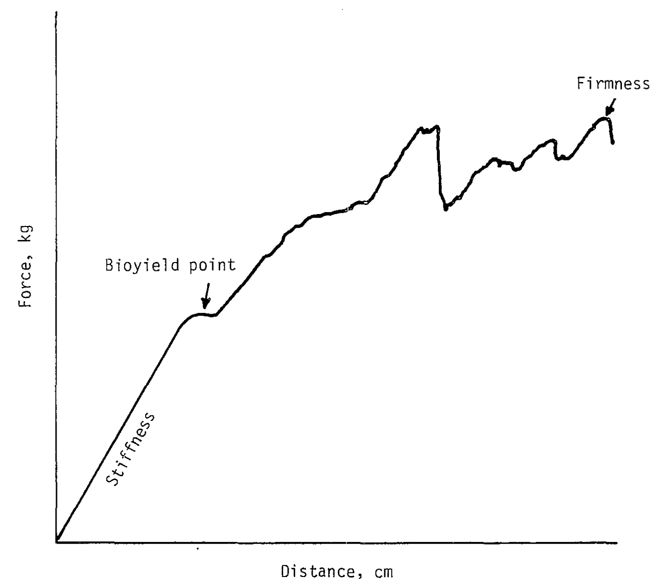


FIG. 2.—The typical force-distance curve of the downstroke of the Ohio curd obtained from the Instron machine.

Effect of WPC Concentration on Textural Properties of Ohio Curd

The mean values of textural parameters of Ohio curds are given in Table 1. For stiffness, curds containing 3%, 4.5%, 5.25%, and 6% WPC had mean values of 3.31, 3.39, 3.60, and 3.99 kg/cm, respectively. For firmness, the curd had mean values of 1.21, 1.31, 1.37, and 1.51 kg, while bioyield points were 0.74, 0.78, 0.81, and 0.87 kg, respectively. The mean values for four replicates of relaxation at 3%, 4.5%, 5.25%, and 6% WPC were 0.24, 0.24, 0.23, and 0.21 min^{-1}, respectively. Curds made with 3% WPC had plasticity 0.84, while those made with 4.5%, 5.25%, and 6% WPC had identical mean values of 0.77.

Effect of Soymilk Concentration on Textural Properties of Ohio Curds

Mean values of five textural parameters of Ohio curds prepared at different soymilk concentration, *i.e.*, H_2O:bean ratio (v/w), are tabulated in Table 2. For stiffness, H_2O:bean ratio at 10:1 was 2.91 kg/cm, at 8:1 was 3.74 kg/cm, and at 6:1 was 4.29 kg/cm. Firmness was 1.46 kg at 10.1, 1.85 kg at 8:1, and 1.81 kg at 6:1. For bioyield point, the mean value at 10:1 was 0.75 kg, at 8:1 was 0.94 kg, and at 6:1 was 1.0 kg. Relaxations at H_2O:bean ratio at 10:1, 8:1, and 6:1 were 0.25, 0.23, and 0.17 min^{-1}, respectively. Plasticities were 0.84, 0.82, and 0.75 for H_2O:bean ratio at 10:1, 8:1, and 6:1, respectively.

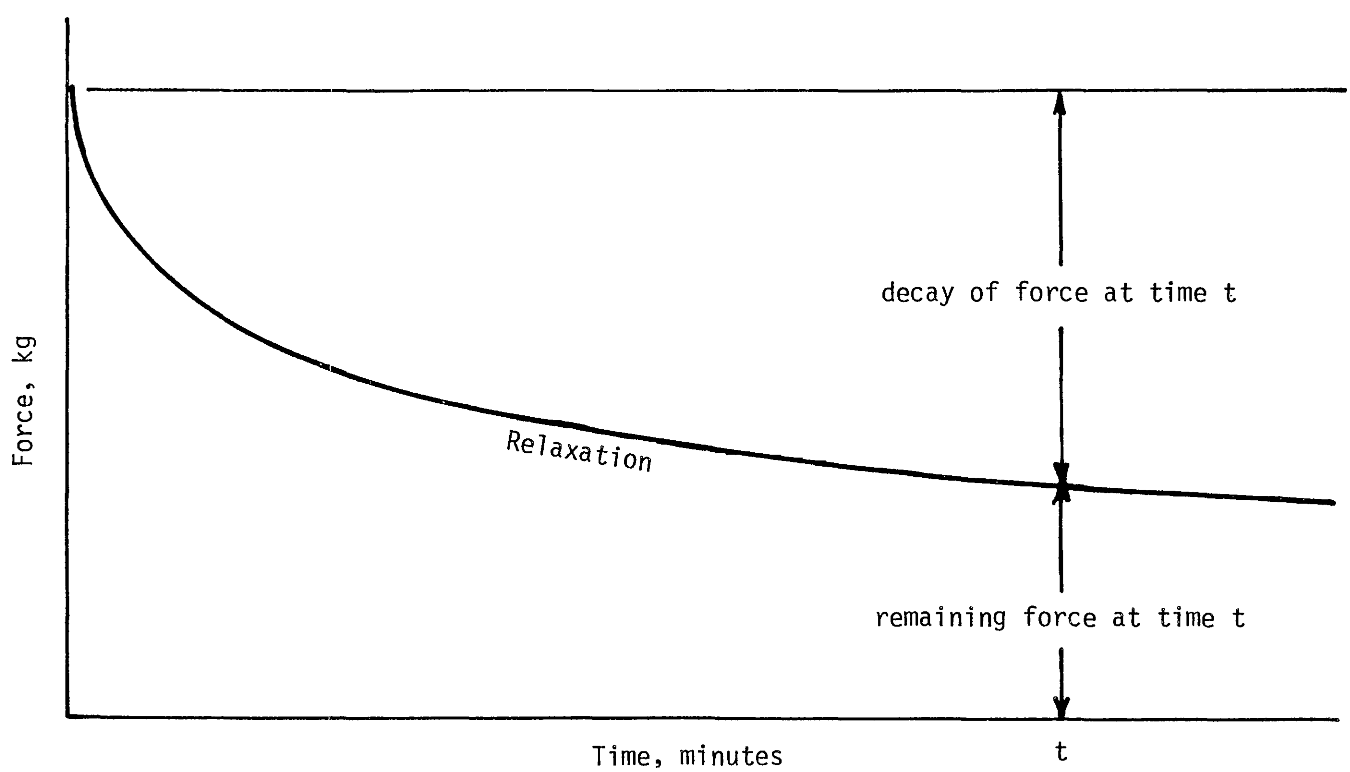


FIG. 3.—The stress relaxation curve of the Ohio curd obtained from the Instron machine.

TABLE 1.—Textural Parameters of Ohio Curd as a Function of WPC Concentration.*

Textural Parameter		N	Concentration of WPC (w/v) 3%	4.5%	5.25%	6%
Stiffness	(kg/cm)	7	3.31	3.39	3.60	3.99
Firmness	(kg)	7	1.21	1.31	1.37	1.51
Bioyield point	(kg)	7	0.74	0.78	0.81	0.87
Relaxation	(min^{-1})	4	0.24	0.24	0.23	0.21
Plasticity		6	0.84	0.77	0.77	0.77

*Mean value of textural parameters of Ohio curds. Soymilk: H_2O:bean = 6:1 (v/w). WPC = 3%, 4.5%, 5.25%, and 6% (w/v). Sodium Protolac was used. N = No. of replicates of curd preparation.

Partial Correlation Among Textural Parameters

As illustrated in Table 3, stiffness was significantly correlated with firmness, bioyield point, and plasticity (at 95% C.I.), having correlation coefficients of 0.75, 0.67, and -0.74, respectively. Firmness showed a significant correlation (at 95% C.I.) with bioyield point and had a correlation coefficient of 0.85. There was a significant correlation between bioyield point and plasticity with a coefficient of -0.63 (at 95% C.I.).

DISCUSSION

Textural Properties of Ohio Curd

The force-distance curve of the downstroke presented a typical pattern as the curve always began with a linear portion until a break was reached, followed by a change in slopes with continuing increasing force, and showing fluctuation in the force by many dips and peaks until the downstroke was ended (Fig. 2). The interpretation of the curve is that as the flat plate plunger contacted and descended into the curd, force began to increasingly build up until it was sufficient to rupture the cells on the top surface. The steepness of the slope, which is defined as stiffness, is a measure of the ease at which the gel is deformed (4).

The force required to rupture the surface (defined as bioyield point) is a measure of gel strength (4) and is most likely tensile strength as the gel surface bends over the edge of the flat plate (9). As the flat plate plunger penetrated the curd, force still increased with a change in slopes and showed fluctuation, presumably due to the flow (the gel is 84-87% water) and the nonhomogeneity of the curd (2, 3, 4, 9). Firmness, the height of the maximum peak (whose reading was affected by the combination of flow properties of the curd, shearing, and compression effects [1]) was thought to be related to

TABLE 2.—Textural Parameters as a Function of Soymilk Concentration.*

Parameter		N	Soymilk Concentration (H_2O:bean v/w) 10:1	8:1	6:1
Stiffness	(kg/cm)	3	2.91	3.74	4.29
Firmness	(kg)	3	1.46	1.85	1.81
Bioyield point	(kg)	3	0.75	0.94	1.00
Relaxation	(min^{-1})	3	0.25	0.23	0.17
Plasticity		3	0.84	0.82	0.75

*Mean values of textural parameters of Ohio curd. Soymilk: H_2O:bean = 10:1, 8:1, and 6:1 (v/w). WPC (Sodium Protolac) = 6% (w/v). N = No. of replicates of curd preparation.

the cohesiveness — the strength of the internal bonds making up the body of the product (8).

For the relaxation curve, Peleg and Calzada (6) reported that the stress-relaxation curve was dependent on the deformation history of the material and the absolute and relative magnitudes of the Maxwell model's elements. After a long relaxation time ($t > \infty$), the generalized Maxwell body may approach zero force or a constant force depending on the absence or presence of an elastic element parallel to the rest of the Maxwell element.

Shama and Sherman (7) stated that the food materials which are viscoelastic in nature show relaxation patterns somewhere between the ideal elastic solids which do not exhibit stress-relaxation and pure fluids which relax instantaneously. Therefore, the relaxation curve of the Ohio curd showed a sharper drop in the beginning and then leveled off as time approached infinite. The extent of this level-off depended on the internal structure of the gel when the relaxation time was standardized at a certain period. Furthermore, the indicators of the gel structure, the stiffness, bioyield point, and

TABLE 3.—Partial Correlation Coefficients Among Textural Parameters of Ohio Curds.

Textural Parameter	Firmness Coefficient	Firmness Prob > |R|	Bioyield Point Coefficient	Bioyield Point Prob > |R|	Plasticity Coefficient	Plasticity Prob > |R|
Stiffness	0.752	1.22×10^{-2}	0.665	3.58×10^{-2}	—0.738	1.48×10^{-2}
Firmness	—	—	0.851	1.80×10^{-3}	—0.632	5.01×10^{-2}
Bioyield Point	0.851	1.80×10^{-3}	—	—	—0.633	4.96×10^{-2}

$a = 0.05$

firmness, failed to show the correlations with the relaxation as indicated by the partial correlation coefficients at 95% C.I. Thus the relaxation was not a probable texture parameter for this product.

The nonhomogeneity of the curd was thought to be the cause of the invalidity of the relaxation. Since plasticity was an estimated value, its suitability as a textural parameter for the Ohio curd was questionable and needs to be further studied. When the estimation is based on the relaxation curve, at a standardized relaxation time of 4.4 minutes, it should be related to the relaxation of the curd. However, the partial correlation coefficient revealed no such relationship. Thus its validity as a parameter for the textural properties of the curd was questioned. Therefore, both the relaxation and the plasticity were considered as not suitable for the textural parameters for Ohio curd.

Since stiffness was defined as a measure of the ease of breaking the gel, it should be related to the bioyield point (a measure of gel strength) because both are affected by gel structure. This is supported by the partial correlation coefficient 0.67 at 95% C.I. Firmness is considered to be related to cohesiveness which reveals the internal bonding strength of the structure. Therefore, it is also related to the stiffness and bioyield point and had correlation coefficients of 0.75 and 0.85 at 95% C.I., respectively. Thus, stiffness, firmness, and bioyield point were suggested as possible textural parameters for the Ohio curd.

Curds made from soymilk with water:bean ratio at 6:1 and 8:1 had higher stiffness and firmness than those of the 10:1. There was no indication between 6:1 and 8:1. Presumably, the curds did not show sufficient difference in textural properties when prepared at those soymilk concentrations. Bioyield point was not affected by the soymilk concentrations, probably due to the protein-lipid film on the surface of the curds.

REFERENCES

1. Bourne, M. C. 1966. Measure of shear and compression components of puncture test. J. Food Sci., 31:282.
2. Bourne, M. C., J. C. Moyer, and D. B.Hand. 1966. Measurement of food texture by a Universal Testing Machine. Food Technol., 20:522.
3. Kalab, M., P. W. Voisey, and D. B. Emmons. 1971. Heat-induced milk gels. II. Preparation of gels and measurement of firmness. J. Dairy Sci., 54:178.
4. Kramer, A. and J. V. Hawbecker. 1966. Measuring and recording rheological properties of gels. Food Technol., 20:209.
5. Mohesnin, N. N. 1970. Physical Properties of Plant and Animal Materials. Vol. 1. Structure, Physical Characteristics and Mechanical Properties. Gordon and Breach Science Publishers, New York, p. 95.
6. Peleg, M. and J. F. Calzada. 1976. Stress relaxation of deformed fruits and vegetables. J. Food Sci., 41:1325.
7. Shama, F. and P. Sherman. 1973. Stress relaxation during force-compression studies on foods with Instron Universal Testing Machine and its implications. J. Texture Studies, 4:353.
8. Szczesniak, A. S. 1963. Classification of textural characteristics. J. Food Sci., 28:383.
9. Voisey, P. W. and J. M. deMan. 1976. Application of Instrument for Measuring Food Texture in Rheology and Texture in Food Quality. AVI Publishing Co., Inc., Westport, Conn., pp. 142-143.
10. Yao, M. L. and A. C. Peng. 1976. The effect of coagulants on protein content and amino acid composition of soybean-cheese whey curd. Ohio Agri. Res. and Dev. Ctr., Research Circular 250, Food Processing and Technology 1979: A Summary of Research, pp. 48-51.

Quality Evaluation of New Potato Cultivars — Before and After Storage — for Chip Manufacture[1]

WILBUR A. GOULD[2]

INTRODUCTION

Evaluation of potato cultivars before and after storage for chip manufacture has been under investigation for several years by researchers at the Ohio Agricultural Research and Development Center (1). Previous work has shown wide differences among cultivars as to yield of chips, specific gravity, quality of chips (color in particular), and storability prior to chipping (*i.e.*, suitable for chip manufacture after storage).

Recent evaluation of chip cultivars has indicated another serious problem, blisters following chip manufacture. Studies from other workers (2, 5, 6) have elucidated cultivar variance in canning, chipping, and processing. These data suggest studies are necessary for cultivar adaptation and use by the industry.

The long-range objective of this study was to evaluate new cultivars considered acceptable as to grower characteristics (yield, disease resistance, etc.) for suitability for chip processing, both before and after storage.

MATERIALS AND METHODS

The potatoes for this study were produced on six farms located throughout Ohio during the period 1978 to 1982. Eight cultivars or selections were evaluated during this period and were grown at six or more of the locations. They were produced using standard cultural practices of the commercial growers who cooperated in the study. Production data are published elsewhere.

Tubers from each location were mechanically harvested and samples from each replicate were transported to The Ohio State University Food Processing Laboratory, Columbus, where a portion of each lot was chipped immediately. Other portions were stored at 40° F (4.4° C), 45° F (7.2° C), and 55° F (12.8° C) with 90% RH (± 5%) for 6 months and subsequently chipped. In addition, specific gravity and tuber count per 8-lb sample were determined prior to storage.

The potatoes were abrasively peeled and mechanically sliced into 16-18 slices per inch. The slices were washed in cold water and immediately fried in oil with a 375° F temperature and a 350° F outlet temperature for 110 to 125 seconds (moisture content of less than 2.0%). The manufactured chips were objectively evaluated for color using the Agtron colorimeter with the red mode standardized at 0 and 90 with respective color reference disc black at 0 and gray at 90 (higher numbers = better color).

Not all cultivars or selections were included for the full duration of the study as they proved consistently superior or inferior, or they were unavailable.

RESULTS AND DISCUSSION

Table 1 shows the raw product data for specific gravity, Agtron red color, and percentage of blisters by year for the eight cultivars. Year-to-year variation for specific gravity is only .005 ± .0009 for all of the cultivars, with the lowest cultivars Michimac, averaging 1.066 ± .0035, and Neb A129.69, averaging 1.067 ± .0055. Denali and Atlantic cultivars had the highest specific gravity (1.084 ± .005 and 1.081 ± .0057, respectively). Norchip had a specific gravity of 1.074 ± .004 for these 5 years.

All of the cultivars had good chip color at harvest, with an average Agtron reading of 56 ± 4.1. W 718, Norchip, and Atlantic cultivars produced the lightest colored chips, with cultivar Neb A129.69 having the poorest color, although acceptable.

The cultivars differed significantly at harvest in the percentage of blisters, with Atlantic and Denali having the lowest percentage of blistered chips, while Neb A129.69 had significantly more blisters. After storage and reconditioning, the percentage of blisters did not differ significantly due to storage temperature or number of days of reconditioning, although blisters were

[1]The cooperation of E. C. Wittmeyer, Floyd Lower, Dave Kelly, and the growers is greatly appreciated. The assistance of Joe Dalmasso, Greg Leighton, Stan Sadel, Jr., and Hope Hart is sincerely acknowledged.

[2]Professor, Dept. of Horticulture.

TABLE 1.—Specific Gravity Evaluation of Potato Cultivars for Chipping Over a 5-Year Period.

	Specific Gravity by Years						
Cultivars	1978	1979	1980	1981	1982	X	±
W 718	1.070	1.068	1.060	1.069	1.068	1.068	0.006
Norchip	1.078	1.073	1.070	1.076	1.076	1.074	0.004
Katahdin	1.068	1.066	1.062	1.069	1.071	1.068	0.004
ND8891-3	1.074	1.071	1.071	1.074		1.070	0.006
Atlantic	1.085	1.083				1.081	0.005
Denali	1.086		1.078	1.083	1.088	1.084	0.005
Michimac		1.066	1.062	1.069		1.066	0.003
Neb A129.69			1.062	1.067	1.073	1.067	0.005

TABLE 2.—Agtron Red Color of Potato Cultivars Over a 5-Year Period Following Storage at Given Temperatures After Reconditioning for 1, 10, and 20 Days.

Cultivar	Year	Before Storage	5°C (40°F)			7.5°C (45°F)			10°C (50°F)			12.5°C (55°F)		
			1*	10	20	1	10	20	1	10	20	1	10	20
W 718	1978	54.0	21.0	35.5	48.0	51.0	54.0	59.0	62.0	58.0	61.0	64.0	59.0	57.0
	1979	62.0	25.6	42.8	40.5	50.3	45.7	48.3	53.0	56.8	58.0	62.5	59.8	57.0
	1980	58.7	29.8	45.8	48.3	56.2	58.0	56.6	56.5	53.2	56.6	57.3	41.0	57.0
	1981	62.6	—	—	—	47.2	55.8	52.8	51.2	56.3	53.3	60.8	54.3	60.0
	1982	58.3	25.2	60.7	57.0	38.2	48.9	59.7	—	—	—	—	—	—
	X	59.1	25.4	46.1	48.5	44.6	52.5	55.3	56.4	57.0	58.0	61.4	55.2	58.4
	±	4.3	4.4	12.9	8.3	13.0	6.2	5.7	5.4	3.8	3.9	3.4	10.5	2.0
Norchip	1978	54.0	27.0	42.0	42.0	45.0	50.0	57.0	59.0	58.0	60.0	60.0	59.0	53.0
	1979	62.0	29.3	40.3	42.7	49.5	43.0	44.0	55.7	57.2	56.0	63.8	58.8	58.5
	1980	56.6	27.0	42.0	43.2	55.6	48.3	54.8	56.2	53.8	56.8	56.8	—	—
	1981	61.9	—	—	—	46.3	50.8	52.2	53.0	55.7	53.7	57.3	59.0	—
	1982	59.8	27.8	47.7	52.4	34.8	47.3	51.4	60.7	61.8	61.6	61.1	58.6	58.7
	X	58.9	27.8	43.0	45.1	42.2	47.9	51.9	56.9	57.3	57.6	59.8	59.1	56.7
	±	4.0	1.2	3.7	5.2	13.1	3.9	5.4	3.9	4.0	4.0	3.5	0.6	2.9
Katahdin	1978	54.0	19.0	31.0	41.0	35.0	44.0	51.0	55.0	58.0	61.0	62.0	58.0	53.0
	1979	58.0	20.3	30.8	41.0	27.7	32.0	39.7	40.3	45.2	52.5	50.8	46.5	56.0
	1980	50.3	26.2	40.5	46.7	49.2	55.2	49.8	49.3	56.0	55.0	56.5	45.5	38.0
	1981	57.4	—	—	—	40.7	45.8	54.3	49.3	49.3	52.5	57.0	53.5	51.5
	1982	56.1	20.3	40.8	54.7	47.9	45.2	53.0	58.0	57.8	56.9	61.5	59.2	59.1
	X	54.4	21.5	35.8	45.9	36.1	44.4	49.6	50.4	53.3	55.6	57.6	52.5	51.5
	±	3.6	3.6	4.9	6.9	10.8	11.6	7.3	8.9	6.4	4.3	5.6	6.9	10.6
ND8891-3	1977	52.5	24.0	33.4	37.8	46.4	53.5	—	47.4	53.5	52.0	55.7	31.0	33.0
Crystal	1978	54.0	17.0	30.0	34.0	46.0	48.0	54.0	55.0	58.0	57.0	64.0	58.0	51.0
	1979	60.0	29.5	39.7	40.7	40.7	42.3	47.0	54.8	57.2	55.7	58.3	59.3	53.7
	1980	50.2	28.3	40.0	45.2	56.8	53.4	53.8	55.0	50.8	57.0	54.2	36.8	44.0
	1981	61.1	—	—	—	51.7	52.0	55.5	56.5	51.5	56.2	56.8	55.7	49.0
	X	55.6	24.7	35.8	39.4	48.3	49.8	52.6	53.7	54.2	55.6	57.8	48.2	46.1
	±	5.5	6.3	5.0	5.6	8.1	5.6	4.3	4.6	3.6	2.5	4.9	14.2	10.4
Atlantic	1977	59.0	27.5	40.2	41.7	53.6	55.5	—	56.0	54.0	—	59.3	—	—
(3 years)	1978	53.0	24.0	34.0	45.0	52.0	55.0	61.0	57.0	58.0	58.0	57.0	57.0	53.0
	1979	64.0	29.7	48.8	54.3	33.3	43.0	53.3	55.0	59.8	59.2	59.8	61.5	65.0
	X	58.7	27.1	41.0	47.0	46.3	51.2	57.2	56.0	57.3	58.6	58.7	59.25	59.0
	±	5.5	2.9	7.4	6.3	10.2	6.3	3.9	1.0	2.9	0.6	1.4	2.3	6.0
Denali (4 years)	1978	54.0	22.0	40.0	48.0	50.0	53.0	57.0	62.0	58.0	61.0	61.0	61.0	56.0
	1980	46.5	27.0	40.8	45.0	56.5	58.0	60.2	59.7	56.3	61.0	62.3	—	—
	1981	61.9	—	—	—	51.0	50.8	54.7	52.4	55.8	55.7	54.8	56.5	53.0
	1982	58.9	32.2	42.2	55.4	39.9	49.4	56.8	64.0	59.9	61.4	63.1	58.9	60.6
	X	55.3	27.1	41.0	49.5	49.4	52.8	57.2	59.5	57.5	59.8	60.3	58.8	53.2
	±	7.7	5.1	1.1	5.2	8.3	4.3	2.8	5.8	2.1	2.9	4.2	2.3	8.8
Michimac	1979	58.0	22.4	31.8	38.6	31.0	44.5	44.8	49.8	50.4	54.5	47.3	53.5	47.7
(3 years)	1980	51.8	20.2	34.0	40.3	50.2	49.0	50.2	47.0	51.2	53.5	51.7	32.0	57.0
	1981	59.2	—	—	—	45.17	40.5	49.8	52.0	48.8	48.5	58.5	55.3	56.0
	X	56.3	21.3	32.9	39.5	42.1	44.7	48.3	49.6	50.1	52.2	52.5	46.9	53.6
	±	3.7	1.2	1.1	0.9	9.6	4.3	2.7	2.5	1.2	3.0	5.6	11.7	4.7
Neb A 129.69	1980	47.3	32.7	43.3	47.0	53.2	55.6	50.6	50.0	54.8	56.2	47.3	44.0	52.0
(3 years)	1981	49.4	—	—	—	38.7	48.2	48.8	45.3	44.0	48.0	52.3	50.4	46.0
	1982	52.1	33.3	50.2	53.4	39.8	47.6	51.8	58.3	54.8	57.3	57.2	54.4	55.8
	X	49.6	33.0	46.8	50.2	43.9	50.5	50.4	51.2	51.2	53.8	52.3	49.6	51.3
	±	2.4	0.3	3.5	3.2	7.3	4.0	1.5	6.5	5.4	4.7	5.0	5.2	4.9

*Days of reconditioning after storage.

TABLE 3.—Percent Blisters of Potato Cultivars Over a 5-Year Period Following Storage at Given Temperatures After Reconditioning for 1, 10, and 20 Days.

			5°C (40°F)			7.5°C (45°F)			10°C (50°F)			12.5°C (55°F)		
Cultivar	Year	Before Storage	1	10	20	1	10	20	1	10	20	1	10	20
W718	1978	30.0	24.0	36.0	29.0	26.0	34.0	18.0	31.0	22.0	34.0	33.0	19.0	18.0
	1979	21.0	32.0	32.0	59.0	40.0	44.0	15.0	36.0	36.0	58.0	36.0	29.0	65.0
	1980	32.4	43.3	40.0	38.3	58.0	48.0	38.0	46.0	40.0	54.0	50.0	20.0	70.0
	1981	17.8	—	—	—	16.7	10.0	10.0	20.0	23.3	15.0	35.0	8.3	40.0
	1982	31.0	32.0	18.0	18.0	30.0	28.0	17.0	21.0	30.0	32.0	41.0	26.0	15.0
	X	26.4	32.8	31.5	36.1	34.1	32.8	19.6	30.8	30.3	38.6	39.0	20.5	41.6
	±	7.3	9.7	11.0	20.5	20.7	19.0	14.0	13.0	9.0	21.5	8.5	10.4	27.5
Norchip	1978	19.0	36.0	19.0	22.0	16.0	15.0	17.0	14.0	9.0	15.0	16.0	11.0	5.0
	1979	17.0	22.0	35.0	22.0	23.0	32.0	10.0	29.0	31.0	38.0	30.0	30.0	42.0
	1980	29.1	30.0	48.0	41.7	60.0	22.0	42.0	28.3	38.0	42.0	40.0	—	—
	1981	25.6	—	—	—	6.0	13.3	3.3	21.7	20.0	6.7	18.3	15.0	—
	1982	27.0	31.0	20.0	21.0	22.0	12.0	18.0	12.0	11.0	9.0	15.0	15.0	8.0
	X	23.5	29.8	30.5	26.7	25.4	18.9	18.1	21.0	21.8	22.1	23.9	17.8	18.3
	±	6.1	7.0	14.5	10.4	27.0	10.0	19.4	8.5	14.5	17.7	12.5	9.5	18.5
Katahdin	1978	16.0	13.0	20.0	22.0	23.0	18.0	16.0	22.0	14.0	9.0	29.0	12.0	2.0
	1979	16.0	26.0	34.0	48.0	25.0	50.0	21.0	32.0	28.0	50.0	21.0	45.0	49.0
	1980	20.0	28.3	38.3	48.3	42.0	40.0	34.0	33.3	35.0	56.0	38.3	25.0	50.0
	1981	17.8	—	—	—	6.7	23.3	18.3	28.3	15.0	10.0	20.0	23.3	25.0
	1982	31.0	26.0	13.0	12.0	32.0	19.0	17.0	25.0	18.0	10.0	20.0	14.0	11.0
	X	20.2	23.3	26.3	32.6	25.7	30.1	21.3	28.1	22.0	27.0	25.7	23.9	27.4
	±	7.5	7.7	12.7	18.2	17.7	16.0	9.0	5.7	10.0	23.5	9.2	16.5	24.0
Crystal	1977	2.7	16.0	26.0	19.0	22.0	13.0	16.0	10.0	4.0	9.0	20.0	11.0	3.0
	1979	19.0	37.0	24.0	44.0	29.0	47.0	11.0	31.0	34.0	32.0	45.0	51.0	48.0
	1980	32.4	48.3	36.7	40.0	64.0	28.0	68.0	35.0	27.5	52.5	46.7	35.0	35.0
	1981	21.7	—	—	—	13.3	15.0	1.7	35.0	20.0	5.0	20.0	16.7	10.0
	X	18.2	33.8	28.9	34.3	32.1	25.8	24.2	27.8	21.4	24.6	32.0	28.4	24.0
	±	14.9	16.2	6.4	12.5	25.4	17.0	33.2	12.5	15.0	23.8	13.4	20.0	22.5
Atlantic (3 years)	1977	0.5	—	—	—	—	—	—	—	—	—	—	—	—
	1978	11.0	27.0	19.0	16.0	19.0	11.0	13.0	9.0	5.0	3.0	15.0	12.0	0
	1979	8.0	18.0	19.0	40.0	25.0	25.0	43.0	20.0	30.0	39.0	24.0	36.0	42.0
	X	6.5	22.5	19.0	28.0	22.0	18.0	28.0	14.5	17.5	21.0	19.5	24.0	21.0
	±	5.3	4.5	0.0	12.0	3.0	7.0	15.0	5.5	12.5	18.0	4.5	12.0	21.0
Denali (4 years)	1978	6.0	11.0	13.0	10.0	13.0	4.0	1.0	4.0	4.0	2.0	9.0	5.0	2.0
	1980	20.6	38.3	35.0	38.0	40.0	38.0	40.0	36.7	36.7	46.7	33.3	—	—
	1981	10.8	—	—	—	18.3	8.3	1.7	15.0	8.3	0	11.7	8.3	0
	1982	17.0	25.0	10.0	9.0	13.0	9.0	8.0	9.0	6.0	5.0	22.0	6.0	7.0
	X	13.6	24.8	19.3	19.0	21.1	14.8	12.7	16.2	13.8	13.4	19.0	6.4	3.0
	±	7.3	13.7	12.5	14.5	13.5	17.0	19.5	16.4	16.4	22.4	12.2	1.7	2.5
Michimac (3 years)	1979	10.0	18.0	39.0	31.0	28.0	39.0	27.0	38.0	18.0	48.0	34.0	24.0	32.0
	1980	20.7	31.7	43.3	58.3	48.0	32.0	28.0	36.7	26.7	48.3	41.7	20.0	70.0
	1981	18.6	—	6.7	6.7	26.7	10.0	13.3	17.6	21.7	10.0			
	X	16.4	24.9	41.2	44.7	27.6	25.9	20.6	30.5	18.2	36.5	30.8	21.9	37.3
	±	5.4	6.9	2.2	13.7	20.7	16.2	10.7	5.0	8.4	17.5	12.5	2.0	30.0
Neb A129.69 (3 years)	1980	56.1	38.3	65.0	56.7	66.0	34.0	58.0	30.0	44.0	42.0	41.7	56.7	20.0
	1981	16.9	—	—	—	15.0	26.7	15.0	28.3	18.3	10.0	26.7	31.7	20.0
	1982	37.0	34.0	20.0	27.0	25.0	25.0	22.0	35.0	22.0	13.0	28.0	35.0	20.0
	X	36.7	36.1	42.5	41.8	38.2	28.2	31.7	31.1	28.1	22.3	32.3	41.1	20.0
	±	19.6	2.1	22.5	14.8	13.2	3.2	16.7	2.8	9.8	12.3	5.6	9.4	0

increased by 4% on an average for all cultivars.

The cultivars varied greatly in their ability to fry light in color after storage and reconditioning. None of the cultivars was suitable for chip manufacture directly from 40° F (5° C) storage with 1 day of reconditioning. However, after 10 days of reconditioning, W 718, Norchip, and Neb A129.69 were acceptable in terms of color. At 20 days of reconditioning after 40° F (5° C) storage, all cultivars were suitable for chip manufacture except Michimac. After storage at 45° F (7.5° C) for 6 months and 1 day of reconditioning, only Katahdin was unacceptable for chip manufacture. After 10 days of reconditioning at room temperature following 6 months of storage at 45° F (7.5° C), this cultivar was also acceptable. After 6 months of storage at 50° F (10° C) and 55° F (12.8° C), all cultivars were suitable for chip manufacture after 1 day of reconditioning. All cultivars except Michimac produced chip color after 6 months of storage equal to or better than the chip color prior to storage.

These data indicate that for these cultivars stored under these conditions, reconditioning is not necessary if stored at 50° F (10° C) and 55° F (12.8° C). However, improved color is noted for all cultivars reconditioned for 10 days if stored at 45° F (7.5° C) for 6 months, and 20 days of reconditioning for most cultivars if stored at 40° F (5° C) after 6 months of storage.

In summary, Denali rated overall superior compared to the other cultivars in this study. Denali's specific gravity was the greatest, the color was equal to or better than the other cultivars, and the percentage of blisters was among the lowest compared to the other cultivars.

REFERENCES

1. Gould, W.A., B. Hair, and A. Baroudi. 1979. Evaluation of potato cultivars before and after storage regimes for chipping. Am. Potato J., 56:133-144.
2. Malone, J. W., R. H. True, and E. S. Barden. 1977. Varietal differences in potato mealiness as related to composition. University of Maine at Orono, Research in the Life Sciences, 25(4):1-5.
3. Pisarczyk, J. M., R. C. Rowe, E. C. Wittmeyer, F. I. Lower, W. A. Gould, D. M. Kelly, and R. C. Henne. 1983. 1982 Ohio potato cultivar trials. The Ohio State Univ., Ohio Agri. Res. and Dev. Ctr., Wooster. Hort. Dept. Series No. 525.
4. Reeves, A. F., II. 1982. Potato chip color rating of advanced selections from the Maine potato breeding program. Am. Potato J., 59(8):389-394.
5. Ridley, S. C., J. H. von Elbe, and J. A. Shoenemann. 1980. The evaluation of experimental potato varieties for use in canning. Am. Potato J., 57(9): 407-415.
6. Work, T. M., A. S. Kezis, and R. H. True. 1981. Factors determining potato chipping quality. University of Maine at Orono, Life Sciences and Agr. Exp. Sta., Tech. Bull. 103.

Color Evaluation of Potato Chips

WILBUR A. GOULD and KENT ROGERS[1]

Color is one of the most important attributes of potato chip quality. It is generally the first impression the user makes about the product.

Over the years the industry has used a 10-point color chart to aid in subjective evaluation. In the late 1970's, the Potato Chip/Snack Food Association (PC/SFA) adopted a 5-point color scale with enclosed color charts to aid in subjective evaluation. At the same time the PC/SFA established minimum Agtron color values for the 5-point scale, using Agtron M-30-A operating on the red mode with the instrument standardized with the black disc at 0 and the 90 white disc at 90.

Since these original values for the Agtron were established, the developer of the Agtron upgraded the instrument by adding a green mode and developed and redesigned a new Agtron model (E-5F). The new instrument has two rewarding features in that when the drawer is out the standardizing disc is in position, and if out of standardization it can be noted and restandardized each time. Secondly, the sample is viewed by the instrument from above, *i.e.*, the same as the observer would view it.

The objective of this study was to evaluate several samples (750) using the Agtron M-30-A with the green mode (546 nm) and the red mode (640 nm), and the Agtron E-5F with the green mode (546 nm), infrared mode (800 nm), and a green-red ratio, and establish correlations between the instruments and the PC/SFA color chart.

The data in Table 1 summarize the results of this study and present information which should be helpful to users of the different models of Agtrons. Because of a different red light source in the E-5F, the obtained values do not agree with the red value when using the M-30-A (Fig. 1); however, when operating the instrument on the green mode or the ratio, the values are quite close (Table 1, Figs. 2 and 3). Figures 4, 5, and 6 should be helpful to the user as they show the relationship between PC/SFA color scores M-30-A red and E-5F ratio, and the two instruments for green mode. The data indicate that either the M-30-A or E-5F are statistically similar if reading on green or red mode for M-30-A, or green or ratio mode on E-5F.

The red mode of the E-5F should not be used for chip evaluation. These data also demonstrate a slight difference from the original (old) M-30-A Agtron values (column 2) when compared to the new M-30-A values (column 3). The data indicate quite a difference in the Agtron values in the poorer colored samples. Further, it is important to standardize the instrument with the 90 white disc at 90. It is suggested that the user make these

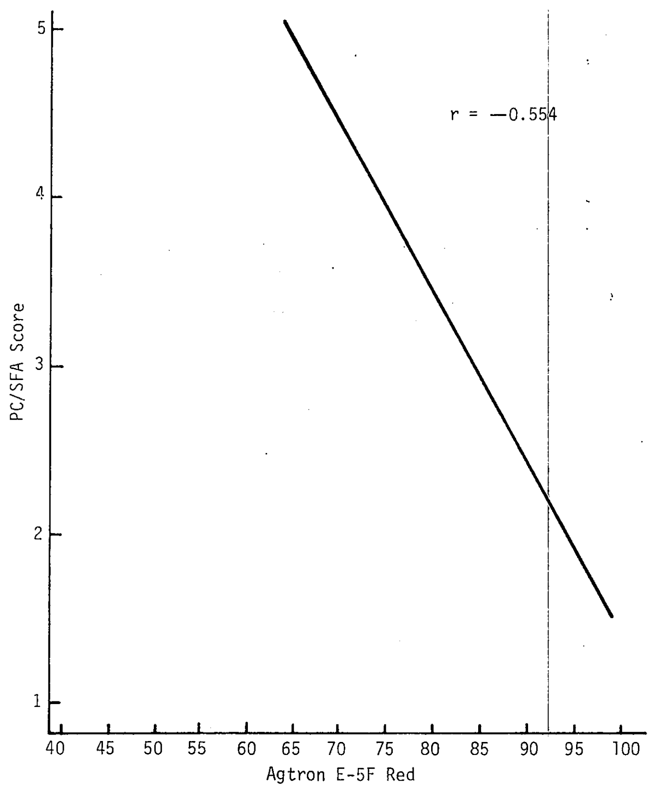


FIG. 1.—PC/SFA score vs. Agtron E-5F infrared.

[1]Professor and former Graduate Research Associate, Dept. of Horticulture.

TABLE 1.—Color Evaluation of Potato Chips, 750 Samples, 1983.

PC/SFA Color Designation	PC/SFA M-30-A Agtron 90-90 Red Mode	New M-30-A Agtron 90-90 Red Mode	New M-30-A Agtron 90-90 Green Mode	E-5F Agtron 90-90 Green Mode	E-5-F Agtron 90-90 Ratio	M-30-A Agtron Calculated Green-Red Ratio
1	65	67	57	64	69	96
2	55	53	45	50	54	78
3	45	40	32	37	38	60
4	35	27	17	24	24	38
5	25	15	4	9	10	22
r		0.88	0.90	0.86	0.89	0.81

corrections for Agtron readings vs. PC/SFA scores when evaluating chips.

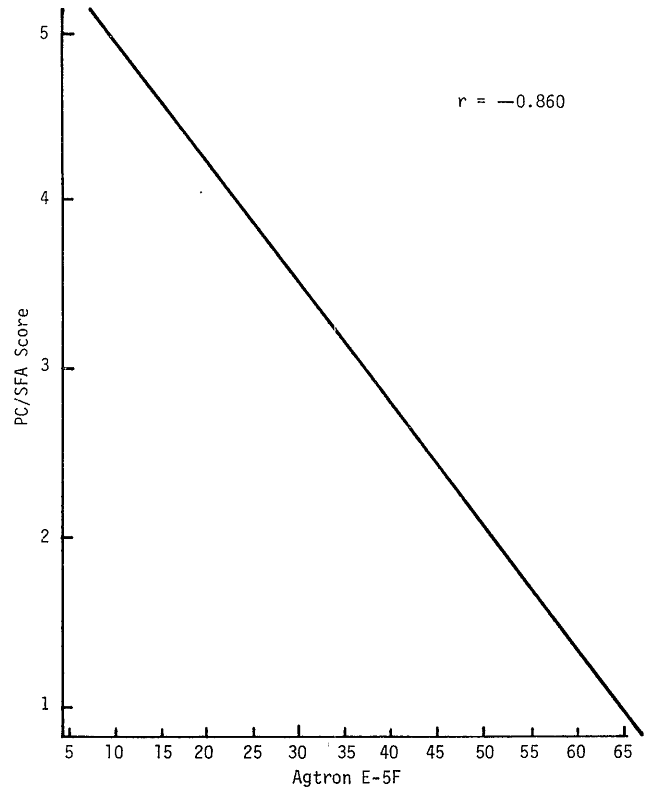


FIG. 2.—PC/SFA score vs. Agtron E-5F green.

REFERENCE

1. Rogers, Kent L. 1983. Comparison of two abridged spectrophotometers and the Potato Chip/Snack Food Association subjective scoring in the measurement of potato chip color. M. S. Thesis, The Ohio State Univ., Columbus.

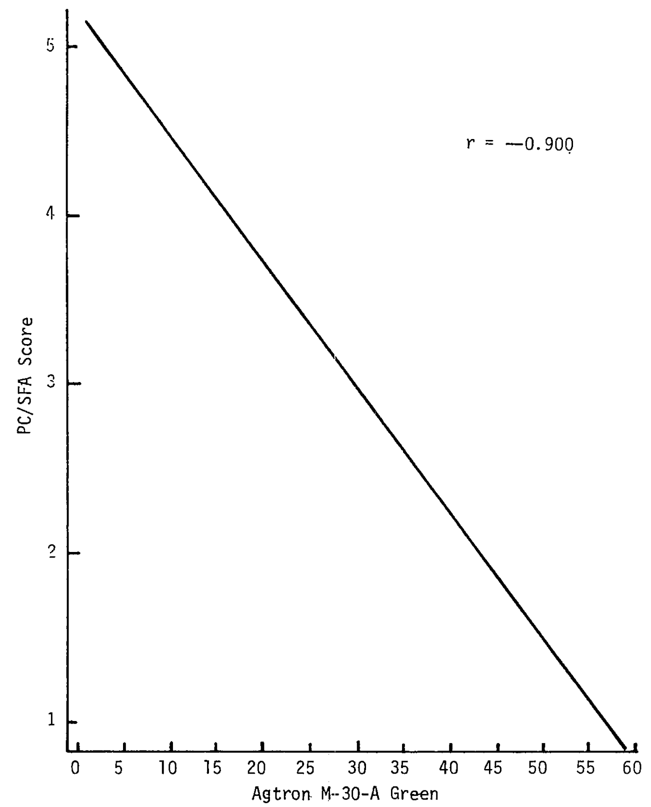


FIG. 3.—PC/SFA score vs. Agtron M-30-A green.

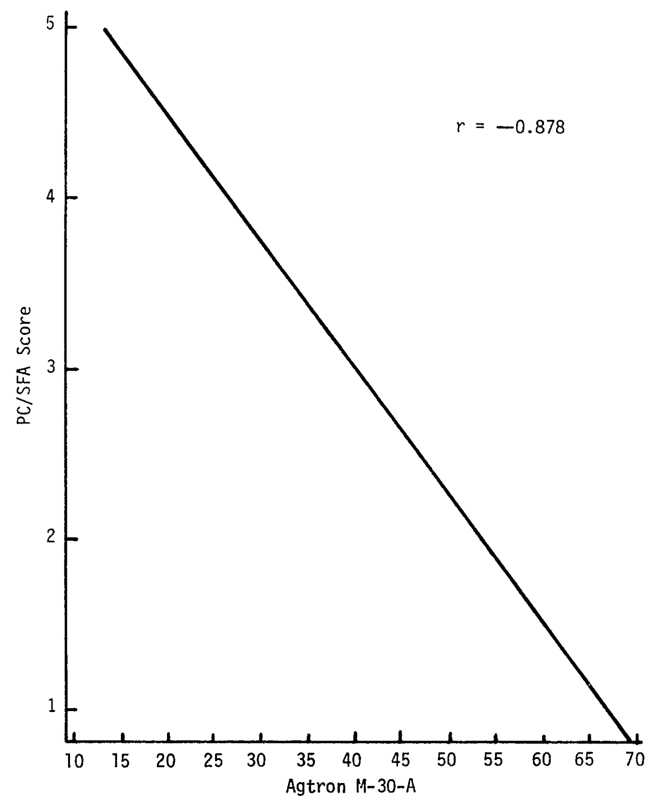


FIG. 4.—PC/SFA score vs. Agtron M-30-A red.

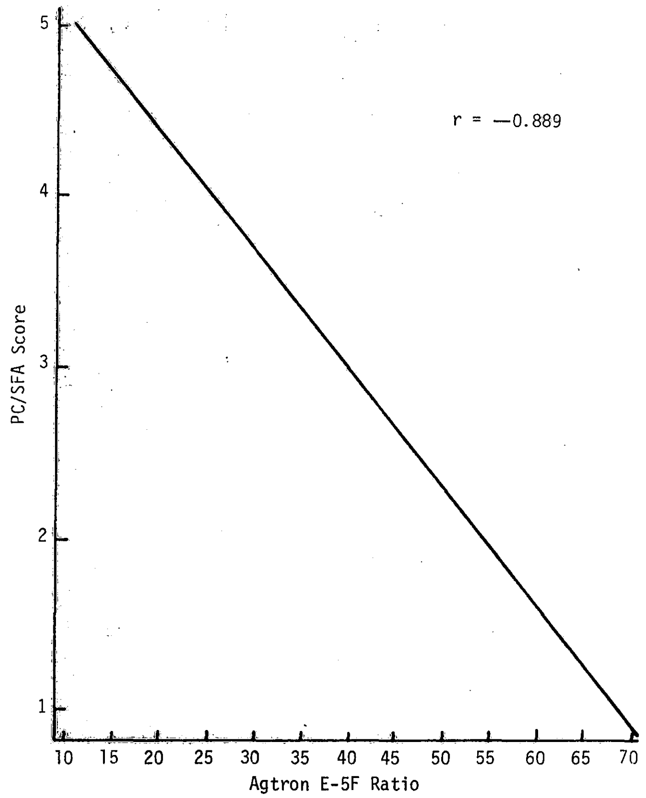


FIG. 5.—PC/SFA score vs. Agtron E-5F ratio.

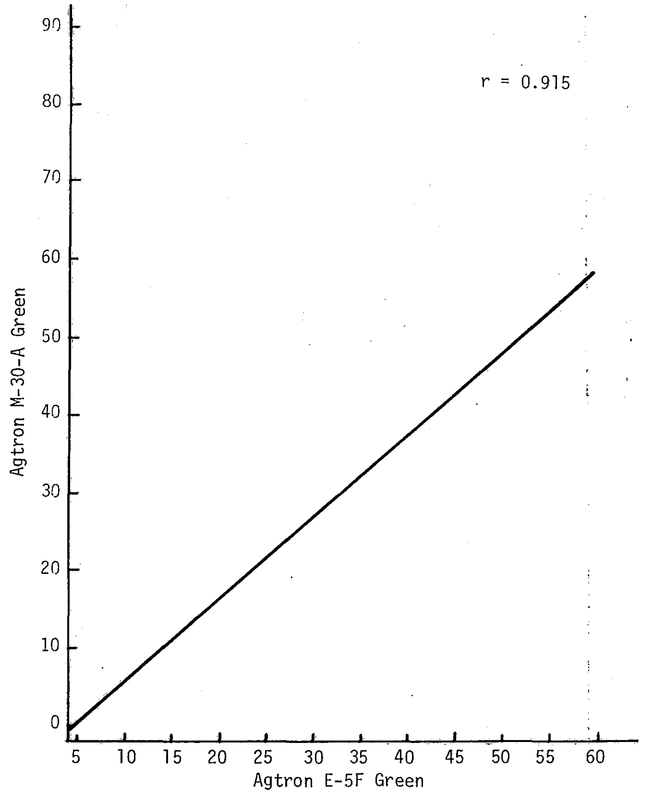


FIG. 6.—Agtron M-30-A green vs. Agtron E-5F green.

Evaluation of Tomato Cultivars for Processing[1]

W. A. GOULD[2], S. Z. BERRY[2], W. D. BASH[3], and J. DALMASSO[4]

INTRODUCTION

Tomatoes in Ohio continue to be an important processing crop, with planted acreage slightly less than 20,000 acres producing more than 400,000 tons. However, Ohio produces less than one-half of the tonnage needed for processing. Ohio ranks second only to California in volume of processed tomatoes, tomato juice, and tomato products.

This study is concerned primarily with evaluating new tomato cultivars for processing. The research is also directed toward improvement of the quality of the various type products packed from tomatoes. The specific objective of the program is to determine the suitability of Ohio grown cultivars, developed in the breeding program, for processing.

MATERIALS AND METHODS

The 1982 and 1983 processing project included 28 cultivars in 1982 and 30 cultivars in 1983 grown in replicated plots under acceptable commercial practices at the OARDC Vegetable Crops Branch near Fremont. Each cultivar was machine harvested using an FMC Western Model with little or no sort on the harvester and bulk handled in 400-lb steel bins. Following harvest, the tomatoes were transported by truck (approximately 100 miles) to The Ohio State University Food Processing Pilot Plant at Columbus for processing. All lots were processed within 24 hours following harvest as peeled whole tomatoes and juice.

Evaluation: Twenty field-run tomatoes were randomly selected and used for objective and subjective raw quality evaluation.

- The tomatoes were classified as globe, pear, blocky, or ovate in ***shape***.
- ***Size*** was determined by weighing a 20-lb sample, counting the number of tomatoes, and then calculating the number per pound.
- ***Stem scar length*** and ***stylar scar length*** were measured objectively by determining the average length in inches of each scar.
- ***Firmness*** was determined subjectively and rated as soft, puffy, medium, and hard.
- The sample was then quartered and extracted using the California Blender system of extraction as follows:
    - **a.** Remove 8.5 lb of tomatoes sampled at random from the lot.
    - **b.** Wash the 8.5 lb sample, quarter and stem the fruits.
    - **c.** Place the sample in a blender and cover with blender lid connected to a vacuum hose.
    - **d.** Start vacuum and when gauge reaches 27 start blender for 5 seconds.
    - **e.** Stop blender, remove the container without breaking vacuum, turn upside down and shake. Return the container to the blender and blend for 1 minute.
    - **f.** Remove the blender lid, insert 14-mesh wire screen into container, and ladle juice (175 ml) into Agtron color dish.
    - **g.** Adjust Agtron calibration if necessary, close drawer of Agtron, and read tomato color.
- The ***color*** was evaluated with the Agtron E-5 instrument sample cup with the instrument calibrated at 48. The color reading was taken directly and recorded as such.
- The ***juice*** was also presented to the Hunter color difference meter D25 D3A in a standard plastic sample cup and the Hunter TCM value, a, L, and b values were determined and the a/b ratio and TCM index were calculated.
- ***Percent soluble solids:*** An Abbe refractometer was used for direct determination of percent soluble solids. The instrument was standardized with distilled water and all readings were converted to 70° C. (For juice the refractive index is also given.)
- ***pH:*** The pH was determined by the glass electrode method (Beckman Zeromatic pH Meter), using 10 ml of tomato juice diluted with 90 ml of distilled water.
- ***Percent total acid as citric:*** The sample used for pH determination was directly titrated using the following equation:

$$\text{Percent acid} = \frac{(\text{No. of ml of 0.1 N NaOH})\ (.0064)}{10 \text{ ml sample}} \times 100$$

- ***Ascorbic acid:*** Ten ml aliquots of tomato juice were diluted with 90 ml of 1% metaphosphoric acid and filtered. A 10 ml aliquot of the filtrate was titrated with 0.2% 2, 6-dichlorophenolindophenol indicator solution. Milligrams of vitamin C were determined by the following formula:

$$\text{Dye factor} \times \text{ml of dye} \times 100 = \text{mg vitamin C}/100\text{ g}$$

- The ***sugar/acid ratio (S/A)*** was calculated by dividing the percent soluble solids by the percent titratable acid.
- ***Consistency*** was measured in seconds by effluxing 150 ml of juice at 70° F through the GOSUC con-

[1]The assistance of Walt Davlin, Ann Hoying, Greg Leighton, Wennie Lloyd, J. D. Montgomery, Paul Pak, Shari Plimpton, Linda Rousch, Stanley Sadel, Jr., Jenny Steyers, and Margaret Watkins is gratefully acknowledged. The cooperation of C. C. Willer and the Vegetable Crops Branch employees is greatly appreciated.

[2]Professors, [3]Assistant Professor, and [4]Instructor, Dept. of Horticulture.

sistometer standardized at 32 seconds with water and a 5/64-inch precision bore orifice.

Preparation and processing of the tomato: All tomatoes were prepared for canning by washing, lye peeling (18% caustic soda and 0.1% Faspeel at 190° F [88° C] for 20 seconds), filling, closing, and processing in a still retort as whole tomatoes. Each lot of whole tomatoes was filled to 10.0-10.5 oz in No. 303 x 406 size fruit enamel tin cans with a 50-grain salt tablet containing 44.5% NaCl, 15% $CaSO_4 \bullet H_2O$, 37% citric acid, and 3.5% $NaHCO_3$, and covered with hot juice (190° F) [88° C] and steam flow closed.

Juice was made from each cultivar of tomato by washing, chopping, preheating to 190°-200° F (88°-93° C), extracting using a 0.023-inch screen in a Langsenkamp extractor, high temperature-short time sterilizing (252° F [122° C], 42 seconds), cooling to 200° F (93° C), filling in 303 x 406 enamel cans, adding a 30-grain NaCl salt tablet, closing, inverting and holding for 3 minutes, and spin cooling to 100° F (38° C) prior to casing and storing.

Grades were determined in accordance with the U. S. Standards for Grades of Canned Tomatoes and Tomato Juice.

RESULTS AND DISCUSSION

The actual data for each cultivar by years as presented in Tables 1 and 2 indicate several potential new cultivars which rated extremely high in quality as either a canned tomato or juice or for both. Specifically, in 1982 Ohio 7870, 8129, 8139, 8144, 8150, A2905, and A2844 were the best of the cultivars for whole packed canned tomatoes. For juice, Purdue 812, Ohio 7864, 7868, 7870, 79122, 8129, 8136, 8152, A510, A525, A585, A2905, 2923, and A2944 were excellent in quality. In 1983 Campbell 4135, Ohio 79122, 08138, 08243, 08258, and 08260 scored the highest for canned whole pack. For juice, Peto 95, Peto 95-93, Campbell 4135, Ohio 7814, 7870, 0831, 0832, 0833, 07825, 079122, 08136, 08239, 08241, 08245, 08258, 08260, 08267, 08290, and 08294 all scored 100 points in quality.

Overall, the 2 years of data show some interesting effects of (probably) climatic conditions during growth. The pH in 1983 was the highest ever recorded, with an average value of 4.46 for these 30 cultivars. Further, the acid values were much higher than normal, averaging 0.44. The higher acid values are important for the superior flavor of Midwestern juice as reflected by the sugar/acid ratios (4.57 higher than the 1982 ratios of 10.14). Also, it should be noted that overall color was improved significantly in 1983.

TABLE 1.—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1982.

Lot No.	1	2	3	4	5	6
Cultivar	**Heinz 2653**	**Heinz 7038**	**Campbell 37**	**Peto 95**	**Purdue 812**	**Ohio 7814**
Raw						
Fruit Shape	Blocky	Blocky	Blocky	Blocky	Blocky	Ovate
No./lb	6.4	4.3	4.2	5.2	8.4	7.0
Stem Scar	1/4 - 3/8 inch	3/8 - 1/2 inch	3/8 - 1/2 inch	1/4 inch	1/4 - 3/8 inch	1/4 inch
Stylar Scar	None	None	1/8 inch	1/8 inch	None	None
Firmness	Hard	Hard	Hard	Hard	Hard	Hard
E-5 Pulp Color	34	38	37	35	32.5	34.5
L	27.6	28.9	25.61	24.40	23.17	26.06
a	28.8	27.33	24.27	25.62	25.56	26.27
b	12.66	12.23	10.18	10.01	9.77	10.75
a/b	2.27	2.23	2.38	2.56	2.62	2.48
TCM	66.33	62.84	72.76	76.96	81.48	71.66
pH	4.12	4.18	4.12	4.22	4.28	4.05
T.A.	0.47	0.35	0.69	0.45	0.45	0.86
S.S.	4.10	4.21	4.99	4.21	4.59	5.65
Canned						
Drained wt. (20)	16.8	20.0	18.0	14.0	16.0	16.0
Wholeness (20)	20.0	19.0	20.0	20.0	20.0	20.0
Color (30)	27.0	26.0	26.5	30.0	29.0	28.0
Defects (30)	29.0	28.0	29.0	30.0	30.0	28.0
Total Score (100)	92.0	93.0	93.5	96.0	95.0	92.0
Grade	A	A	A	B	A	A
Juice						
pH	3.92	4.08	4.05	4.12	4.10	4.0
T.A.	0.68	0.54	0.50	0.63	0.83	0.86
Percent S.S.	4.8	5.2	5.7	5.3	5.8	5.8
Sugar/Acid	7.06	9.63	11.40	8.41	6.99	6.74
E-5	38.0	36.0	40.0	37.0	35.5	35.0
L	25.92	26.67	28.86	26.57	25.50	28.00
a	24.16	25.38	25.16	25.46	27.41	26.86
b	12.91	13.21	14.03	13.36	12.84	13.97
a/b	1.87	1.92	1.79	1.91	2.13	1.92
TCM	82.55	81.23	73.36	80.64	85.60	76.32
GOSUC	39.5	115.4	5.71	45.3	58.1	114.3
Vitamin C	6.7	25.5	18.1	6.0	19.0	18.8
Color (30)	26.0	27.0	26.0	26.0	30.0	27.0
Consistency (15)	15.0	15.0	15.0	15.0	15.0	15.0
Defects (15)	15.0	15.0	15.0	15.0	15.0	15.0
Flavor (40)	36.0	38.0	36.0	38.0	40.0	37.0
Total Score (100)	92.0	95.0	92.0	94.0	100.0	94.0
Grade	A	A	A	A	A	A

TABLE 1 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1982.

Lot No.	7	8	9	10	11	12
Cultivar	Ohio 7825	Ohio 7864	Ohio 7868	Ohio 7870	Ohio 7955	Ohio 7983
Raw						
Fruit Shape	Ovate	Globe-Blocky	Ovate	Blocky	Globe	Ovate
No./lb	7.3	5.1	5.2	7.4	8.3	6.7
Stem Scar	¼ inch	⅜ - ½ inch	¼ - ⅜ inch	¼ - ⅜ inch	¼ inch	¼ inch
Stylar Scar	None	None	⅛ inch	None	None	⅛ inch
Firmness	Hard	Hard	Hard	Hard	Hard	Hard
E-5 Pulp Color	39.5	28.50	33.0	30.5	30.0	35.0
L	27.75	25.23	26.60	25.83	25.93	28.98
a	22.85	30.05	29.17	29.25	29.42	28.17
b	11.41	10.49	10.56	10.34	10.85	11.53
a/b	2.0	2.86	2.76	2.83	2.11	2.44
TCM	65.66	75.60	71.08	73.68	73.12	64.61
pH	4.13	4.13	4.15	4.22	4.22	4.09
T.A.	0.44	0.36	0.50	0.43	0.56	0.67
S.S.	4.21	4.20	4.79	5.0	5.00	5.20
Canned						
Drained wt. (20)	15.5	15.5	15.5	15.0	16.0	15.0
Wholeness (20)	20.0	20.0	20.0	20.0	20.0	20.0
Color (30)	24.5	30.0	30.0	30.0	27.0	29.0
Defects (30)	30.0	28.5	26.0	30.0	30.0	30.0
Total Score (100)	92.0	95.5	92.5	98.0	93.0	92.5
Grade	A	A	A	A	A	A
Juice						
pH		4.05	4.28	4.10	4.30	4.03
T.A.		0.58	0.61	0.85	0.59	0.88
Percent S.S.		4.95	4.8	5.4	4.8	5.8
Sugar/Acid		8.53	7.87	6.35	8.14	6.59
E-5		37.0	35.5	38.5	35.0	38.0
L		25.50	26.47	25.21	26.63	27.23
a		26.56	26.23	24.96	26.52	25.52
b		12.87	12.91	12.37	13.41	13.60
a/b		2.06	2.03	2.02	1.98	1.88
TCM		86.09	82.35	85.70	80.48	78.00
GOSUC		138.5	105.7	51.2	42.5	53.2
Vitamin C		9.4	13.4	7.4	8.0	7.3
Color (30)		29.0	28.0	28.0	26.0	26.0
Consistency (15)		15.0	15.0	15.0	15.0	15.0
Defects (15)		15.0	15.0	15.0	15.0	15.0
Flavor (40)		40.0	38.0	38.0	35.0	36.0
Total Score (100)		99.0	96.0	96.0	91.0	92.0
Grade		A	A	A	A	A

TABLE 1 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1982.

Lot No.	13	14	15	16	17	18
Cultivar	**Ohio 7986**	**Ohio 79122**	**Ohio 8038**	**Ohio 8129**	**Ohio 8136**	**Ohio 8137**
Raw						
Fruit Shape	Ovata	Blocky	Globe-Ovate	Ovate-Blocky	Blocky	Ovate-Blocky
No./lb	5.2	5.4	5.9	6.4	5.2	4.4
Stem Scar	$\frac{1}{4}$ - $\frac{3}{8}$ inch	$\frac{1}{4}$ - $\frac{3}{8}$ inch	$\frac{1}{4}$ - $\frac{3}{8}$ inch	$\frac{1}{4}$ - $\frac{3}{8}$ inch	$\frac{3}{8}$ - $\frac{1}{2}$ inch	$\frac{3}{8}$ - $\frac{1}{2}$ inch
Stylar Scar	None	$\frac{1}{8}$ inch	$\frac{1}{8}$ inch	None	None	$\frac{1}{8}$ - $\frac{1}{4}$ inch
Firmness	Hard	Hard	Med. Hard	Hard	Hard	Med. Hard
E-5 Pulp Color	35.0	30.5	33.5	30.0	37.50	36.0
L	26.96	25.74	27.32	25.58	22.40	24.09
a	26.55	29.21	29.94	27.59	25.94	25.46
b	11.00	10.20	11.87	10.84	9.23	10.13
a/b			2.52	2.54	2.81	2.51
TCM	69.38	74.06	68.40	77.52	85.02	77.58
pH	4.19	4.18	4.22	4.25	4.32	4.29
T.A.	0.46	0.51	0.37	0.58	0.34	0.49
S.S.	4.35	4.40	3.79	4.17	3.99	3.79
Canned						
Drained wt. (20)	15.0	15.5	15.0	18.5	15.0	17.5
Wholeness (20)	20.0	20.0	18.5	19.5	20.0	20.0
Color (30)	27.0	30.0	29.0	30.0	28.0	28.0
Defects (30)	30.0	30.0	30.0	30.0	30.0	27.0
Total Score (100)	92.0	95.5	92.5	98.0	93.0	92.5
Grade	A	A	A	A	A	A
Juice						
pH	4.11	4.11	4.02	4.02	4.02	4.12
T.A.	0.56	0.48	0.44	0.45	0.42	0.48
Percent S.S.	5.4	5.2	4.8	4.8	4.8	4.8
Sugar/Acid	9.64	10.83	10.91	10.67	11.43	10.0
E-5	36.0	35.0	36.0	33.0	31.5	35.5
L	27.09	26.60	25.47	25.57	24.51	27.70
a	26.18	26.85	26.03	27.39	28.28	26.27
b	13.21	12.53	13.21	13.44	12.44	13.36
a/b	1.98	2.14	1.97	2.04	2.27	1.96
TCM	79.33	81.91	83.86	84.70	89.21	83.65
GOSUC	50.8	106.3	42.5	36.4	44.2	44.9
Vitamin C	14.7	17.4	12.1	22.8	16.8	14.7
Color (30)	27.0	29.0	28.0	29.0	30.0	28.0
Consistency (15)	15.0	15.0	15.0	15.0	15.0	15.0
Defects (15)	15.0	15.0	15.0	15.0	15.0	15.0
Flavor (40)	38.0	40.0	38.0	40.0	40.0	38.0
Total Score (100)	95.0	99.0	96.0	99.0	100.0	96.0
Grade	A	A	A	A	A	A

TABLE 1 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1982.

Lot No.	19	20	21	22	23	24
Cultivar	**Ohio 8139**	**Ohio 8144**	**Ohio 8150**	**Ohio 8152**	**Ohio A510**	**Ohio A525**
Raw						
Fruit Shape	Ovate-Blocky	Ovate	Ovate-Blocky	Blocky	Blocky	Globe-Blocky
No./lb	4.8	5.8	6.3	5.0	5.0	5.8
Stem Scar	3/8 - 1/2 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	3/8 - 1/2 inch	3/8 - 1/2 inch	1/4 - 3/8 inch
Stylar Scar	None	None	None	1/8 inch	1/4 inch	1/8 inch
Firmness	Hard	Hard	Hard	Hard	Soft	Hard
E-5 Pulp Color	35.5	37.0	31.0	32.50	29.50	31.50
L	23.63	23.80	25.95	23.73	24.61	25.33
a	23.67	23.02	29.26	27.20	29.38	28.89
b	9.54	9.48	10.92	10.30	10.84	9.71
a/b	2.48	2.43	2.68	2.64	2.71	2.98
TCM	79.35	78.07	71.82	79.51	77.16	75.64
pH	4.28	4.28	4.23	4.31	4.15	4.29
T.A.	0.41	0.50	0.64	0.43	0.40	0.37
S.S.	4.42	4.15	4.42	4.40	4.80	4.29
Canned						
Drained wt. (20)	15.0	17.0	19.0	18.0	15.0	16.0
Wholeness (20)	20.0	20.0	20.0	20.0	20.0	20.0
Color (30)	30.0	23.0	26.0	27.0	29.0	28.0
Defects (30)	30.0	25.5	30.0	26.5	30.0	30.0
Total Score (100)	95.0	95.5	95.0	91.5	94.0	94.0
Grade	A	A	A	A	A	A
Juice						
pH	4.35	3.81	4.12	3.98	4.21	4.12
T.A.	0.28	0.56	0.47	0.49	0.42	0.44
Percent S.S.	4.8	5.7	5.4	5.8	5.5	5.5
Sugar/Acid	17.14	10.18	11.49	11.84	13.10	12.50
E-5	34.0	35.0	35.0	34.0	31.5	34.5
L	25.82	25.81	26.45	25.68	25.19	25.99
a	26.64	26.37	27.30	27.40	28.66	26.59
b	13.21	13.34	13.62	13.07	12.74	12.62
a/b	2.02	1.98	2.00	2.10	2.25	2.11
TCM	83.09	83.00	80.87	84.46	86.70	83.36
GOSUC	101.1	52.0	47.8	51.0	42.1	130.6
Vitamin C	24.1	12.1	24.1	20.1	24.1	11.4
Color (30)	29.0	28.0	28.0	29.0	30.0	30.0
Consistency (15)	15.0	15.0	15.0	15.0	15.0	15.0
Defects (15)	15.0	15.0	15.0	15.0	15.0	15.0
Flavor (40)	37.0	38.0	37.0	38.0	40.0	40.0
Total Score (100)	96.0	96.0	95.0	97.0	100.0	100.0
Grade	A	A	A	A	A	A

TABLE 1 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1982.

Lot No.	25	26	27	28
Cultivar	Ohio A585	Ohio A2905	Ohio 2923	Ohio A2944
Raw				
Fruit Shape	Globe-Blocky	Ovate	Ovate	Blocky
No./lb	5.1	6.6	6.0	6.7
Stem Scar	3/8 - 1/2 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 inch
Stylar Scar	None	None	1/8 inch	None
Firmness	Hard	Hard	Med. Hard	Hard
E-5 Pulp Color	28.5	31.5	28.0	36.0
L	25.26	23.60	22.83	23.89
a	29.10	25.83	27.39	21.94
b	10.51	9.93	9.44	9.22
a/b	2.77	2.60	2.90	2.38
TCM	75.20	80.55	88.28	77.90
pH	4.17	4.25	4.31	4.3
T.A.	0.35	0.40	0.59	0.61
S.S.	4.29	4.20	5.45	4.17
Canned				
Drained wt. (20)	15.0	15.5	14.5	17.0
Wholeness (20)	20.0	20.0	20.0	20.0
Color (30)	29.0	30.0	28.0	29.0
Defects (30)	30.0	30.0	30.0	30.0
Total Score (100)	94.0	95.5	92.5	96.0
Grade	A	A	B	A
Juice				
pH	4.10	4.15	4.12	4.0
T.A.	0.44	0.50	0.51	0.44
Percent S.S.	5.4	5.5	5.5	5.5
Sugar/Acid	12.27	11.0	10.78	12.50
E-5	34.5	36.5	32.5	34.0
L	25.23	25.71	25.18	26.66
a	27.24	26.05	26.90	27.40
b	12.61	12.82	12.49	13.54
a/b	2.16	2.03	2.15	2.02
TCM	86.03	83.66	85.98	80.95
GOSUC	50.0	122.9	46.0	52.0
Vitamin C	12.1	14.7	16.1	18.1
Color (30)	30.0	28.0	30.0	28.0
Consistency (15)	15.0	15.0	15.0	15.0
Defects (15)	15.0	15.0	15.0	15.0
Flavor (40)	40.0	40.0	40.0	40.0
Total Score (100)	100.0	98.0	100.0	98.0
Grade	A	A	A	A

TABLE 2.—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1983.

Lot No.	1	2	3	4	5	6
Cultivar	**Heinz 2653**	**Heinz 1784**	**Peto 95**	**Peto 95-93**	**Campbell 4135**	**Ohio 7814**
Raw						
Fruit Shape	Blocky	Ovate	Blocky	Ovate	Pear	Ovate
No./lb	7.6	8.2	7.4	5.9	8.2	9.7
Stem Scar	1/4 inch	1/4 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 inch	1/4 inch
Stylar Scar	1/8 inch	None	1/8 inch	None	1/8 inch	None
Firmness	Soft	Hard	Hard	Puffy	Puffy	Hard
E-5 Pulp Color	30.5	32	29	30	30	29.5
L	27.28	26.33	25.371	26.15	28.59	26.11
a	30.41	29.09	30.72	30.19	32.77	30.47
b	12.55	12.12	11.83	12.07	12.93	12.13
a/b	2.42	2.40	2.60	2.50	2.53	2.51
TCM	70.96	72.56	75.95	73.81	66.82	72.97
pH	4.61	4.67	4.61	4.60	4.62	4.68
T.A.	0.33	0.32	0.31	0.31	0.36	0.39
S.S.	4.2	4.3	4.2	4.2	5.6	5.4
Vitamin C	25.4	29.0	24.0	23.2	30.1	33.1
Canned						
Drained wt.	19	17	17	19	19	16
Wholeness (20)	18	20	20.	20	20	20
Color (30)	27	27	24	23	30	29
Defects (30)	30	30	30	30	30	30
Total Score (100)	94	94	91	92	99	95
Grade	A	A	B	B	A	A
Juice						
pH	4.48	4.48	4.48	4.46	4.66	4.38
T.A.	0.47	0.44	0.40	0.41	0.31	0.49
Percent S.S.	5.3	5.2	5.3	5.4	6.5	6.4
Sugar/Acid	11.26	11.86	13.30	13.16	20.73	12.97
E-5	33.0	34.0	31.0	32.0	32.5	31.5
a/b	2.19	2.08	2.19	2.19	2.17	2.20
TCM	75.35	73.45	76.49	76.87	75.14	74.56
GOSUC	43.4	50.8	55.5	66.7	71	74.3
Vitamin C	18.9	22.2	15.8	19.7	5.1	7.7
Color (30)	28	28	30	30	30	30
Consistency (15)	15	15	15	15	15	15
Defects (15)	15	15	15	15	15	15
Flavor (40)	38	36	40	40	40	38
Total Score (100)	96	94	100	100	100	98
Grade	A	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1983.

Lot No.	7	8	9	10	11	12
Cultivar	**Ohio 7870**	**0831**	**0832**	**0833**	**07825**	**07983**
Raw						
Fruit Shape	Blocky	Pear	Ovate	Blocky	Ovate	Pear
No./lb	6.2	5.5	6.4	6.7	7.6	8.9
Stem Scar	1/4 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 inch	1/4 inch
Stylar Scar	1/8 inch	None	None	None	None	None
Firmness	Puffy	Puffy	Hard	Puffy	Soft	Puffy
E-5 Pulp Color	29	28	29	30	32	29
L	24.30	24.82	24.60	27.83	27.46	25.06
a	29.47	30.61	30.12	33.36	31.40	30.51
b	10.62	10.69	10.53	12.76	12.18	11.59
a/b	2.77	2.86	2.86	2.61	2.58	2.63
TCM	78.96	78.44	80.13	68.75	69.56	76.98
pH	4.69	4.60	4.60	4.62	4.66	4.60
T.A.	0.33	0.38	0.36	0.34	0.37	0.40
S.S.	5.2	5.4	5.6	5.5	5.0	5.6
Vitamin C	25.8	27.7	29.4	24.5	27.2	29.2
Canned						
Drained wt.	16	16	16	16	18	15
Wholeness (20)	19	20	20	20	20	19
Color (30)	30	27	30	29	27	28
Defects (30)	30	30	29	30	30	28
Total Score (100)	95	93	95	95	95	90
Grade	A	A	A	A	A	A
Juice						
pH	4.40	4.38	4.42	4.68	4.58	4.45
T.A.	0.47	0.47	0.59	0.30	0.28	0.50
Percent S.S.	6.3	6.4	6.0	6.2	6.0	6.2
Sugar/Acid	13.47	13.56	12.02	20.83	21.80	12.42
E-5	31.0	30.0	30.5	30.0	32.0	31.5
a/b	2.29	2.35	2.42	2.35	2.18	2.24
TCM	76.52	77.59	78.52	77.85	76.09	75.69
GOSUC	57.6	91.27	108.2	76.46	55.0	84.4
Vitamin C	22.9	13.3	13.4	11.9	—	25.2
Color (30)	30	30	30	30	30	28
Consistency (15)	15	15	15	15	15	15
Defects (15)	15	15	15	15	15	15
Flavor (40)	40	40	40	40	40	36
Total Score (100)	100	100	100	100	100	94
Grade	A	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1983.

Lot No.	13	14	15	16	17	18
Cultivar	**079122**	**08129**	**08136**	**08138**	**08144**	**08153**
Raw						
Fruit Shape	Blocky	Pear	Ovate	Blocky	Ovate	Ovate
No./lb	5.3	8.4	7.0	7.0	7.1	6.2
Stem Scar	1/4 - 3/8 inch	1/4 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 - 3/8 inch
Stylar Scar	1/8 inch	None	1/8 inch	1/8 inch	None	1/8 inch
Firmness	Hard	Soft	Hard	Hard	Hard	Puffy
E-5 Pulp Color	28	31	28	29	31.5	33
L	26.72	25.11	25.52	26.25	25.26	27.00
a	34.29	29.45	31.40	30.30	29.42	28.33
b	11.18	11.04	11.44	11.76	11.53	11.91
a/b	3.07	2.67	2.74	2.58	2.55	2.38
TCM	72.80	76.28	76.81	73.09	76.28	70.52
pH	4.68	4.62	4.58	4.52	4.50	4.47
T.A.	0.37	0.35	0.36	0.40	0.39	0.40
S.S.	5.4	5.4	4.7	4.0	5.1	5.2
Vitamin C	26.1	29.8	26.4	24.8	25.0	27.3
Canned						
Drained wt.	17	15	15	16	16	17
Wholeness (20)	20	20	20	20	20	19
Color (30)	29	28	30	30	25	25
Defects (30)	30	30	30	30	29	30
Total Score (100)	96	93	95	96	90	91
Grade	A	B	B	A	B	B
Juice						
pH	4.66	4.37	4.65	4.43	4.40	4.40
T.A.	0.31	0.53	0.35	0.50	0.50	0.50
Percent S.S.	6.4	6.4	6.0	5.8	6.0	6.8
Sugar/Acid	20.51	12.08	18.31	11.51	16.98	13.66
E-5	30.5	30.5	31.0	32.0	31.5	35.0
a/b	2.36	2.23	2.37	2.37	2.22	2.07
TCM	79.64	75.78	77.46	76.36	74.30	70.35
GOSUC	65.3	57.2	80.71	47.6	64.7	49.5
Vitamin C	—	14.6	19.2	16.7	5.8	19.5
Color (30)	30	30	30	28	29	28
Consistency (15)	15	15	15	15	15	15
Defects (15)	15	15	15	15	15	15
Flavor (40)	40	38	40	36	39	38
Total Score (100)	100	98	100	94	98	96
Grade	A	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1983.

Lot No.	19	20	21	22	23	24
Cultivar	**08239**	**08241**	**08243**	**08245**	**08297**	**08258**
Raw						
Fruit Shape	Ovate-Blocky	Blocky	Ovate	Blocky	Ovate	Ovate
No./lb	10.7	6.5	9.4	7.6	5.9	6.7
Stem Scar	1/4 inch	1/4 inch	1/4 - 3/8 inch	1/4 inch	1/4 - 3/8 inch	1/4 - 3/8 inch
Stylar Scar	None	1/8 inch	None	1/8 inch	1/8 inch	None
Firmness	Hard	Hard	Puffy	Puffy	Soft	Puffy
E-5 Pulp Color	32	30.5	31	31	31.5	31
L	26.52	25.86	25.42	25.77	26.11	26.36
a	28.68	28.99	29.55	30.12	28.59	30.16
b	11.75	10.95	10.83	11.34	11.08	11.76
a/b	2.44	2.65	2.73	2.66	2.58	2.56
TCM	71.87	75.12	75.94	72.70	74.55	73.24
pH	4.50	4.50	4.64	4.62	4.56	4.50
T.A.	0.40	0.38	0.36	0.37	0.40	0.41
S.S.	4.6	4.9	5.8	5.0	5.1	5.6
Vitamin C	23.0	16.8	31.5	24.2	23.4	27.1
Canned						
Drained wt.	20	15	18	15	16	19
Wholeness (20)	20	20	20	20	20	20
Color (30)	25	29	30	28	27	27
Defects (30)	30	30	29	29	30	30
Total Score (100)	95	94	97	93	93	96
Grade	B	B	A	B	A	A
Juice						
pH	4.48	4.43	4.53	4.39	4.40	4.37
T.A.	0.40	0.47	0.38	0.50	0.50	0.48
Percent S.S.	5.9	6.8	6.7	6.4	6.8	6.4
Sugar/Acid	16.75	14.60	17.82	12.12	13.67	13.20
E-5	34.0	33.5	33.0	32.0	33.5	33.0
a/b	2.05	2.20	2.18	2.21	2.17	2.18
TCM	74.44	74.59	74.71	74.98	73.38	71.99
GOSUC	47.3	51.3	70.7	56.5	70.9	73.5
Vitamin C	10.1	2.2	10.4	11.3	—	7.9
Color (30)	30	30	28	30	29	30
Consistency (15)	15	15	15	15	15	15
Defects (15)	15	15	15	15	15	15
Flavor (40)	40	40	36	40	39	40
Total Score (100)	100	100	94	100	98	100
Grade	A	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1983.

Lot No.	25	26	27	28	29	30
Cultivar	08260	08267	08283	08290	08294	08295
Raw						
Fruit Shape	Ovate	Blocky	Ovate-Blocky	Ovate	Blocky	Pear
No./lb	6.2	5.5	10	8.2	9.1	6.2
Stem Scar	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 inch	1/4 - 3/8 inch	1/4 - 3/8 inch	1/4 inch
Stylar Scar	1/8 inch	1/8 inch	1/8 inch	1/8 inch	None	1/8 inch
Firmness	Puffy	Puffy	Hard	Hard	Puffy	Puffy
E-5 Pulp Color	30	32	33	33	30.5	31
L	25.89	28.65	27.92	27.61	26.08	24.90
a	30.14	32.48	27.80	28.34	30.60	28.89
b	11.57	12.89	12.28	11.73	11.84	11.21
a/b	2.61	2.52	2.26	2.45	2.58	2.58
TCM	75.11	66.58	67.29	67.52	74.03	77.93
pH	4.68	4.65	4.49	4.50	4.60	4.58
T.A.	0.35	0.36	0.42	0.37	0.38	0.30
S.S.	5.6	5.7	4.3	5.2	4.8	4.6
Vitamin C	28.5	24.5	28.3	26.3	19.4	23.4
Canned						
Drained wt.	18	16	16	16	15	15
Wholeness (20)	20	20	20	20	20	20
Color (30)	29	29	21	23	25	25
Defects (30)	30	28	30	30	27	27
Total Score (100)	97	93	87	89	87	87
Grade	A	A	C	C	B	B
Juice						
pH	4.30	4.45	4.37	4.44	4.40	4.42
T.A.	0.46	0.44	0.50	0.48	0.47	0.39
Percent S.S.	6.8	6.4	5.8	6.3	6.4	5.7
Sugar/Acid	14.95	14.49	11.63	13.16	13.73	14.67
E-5	32.5	31.5	35.5	34.0	31.5	33.0
a/b	2.14					
TCM	73.98	75.87	67.90	73.75	74.63	73.78
GOSUC	51.0	59.4	70.6	73.1	59.3	56.1
Vitamin C	8.9	6.6	22.4	20.5	2.5	6.4
Color (30)	30	30	29	30	30	28
Consistency (15)	15	15	15	15	15	15
Defects (15)	15	15	15	15	15	15
Flavor (40)	40	40	39	40	40	39
Total Score (100)	100	100	98	100	100	97
Grade	A	A	A	A	A	A

Aseptic Processing of Diced Tomatoes

WINSTON D. BASH and WILBUR A. GOULD[1]

INTRODUCTION

Aseptic processing and packaging has in the past few years progressed from the novel to an accepted processing system for a narrow range of fluid to semi-viscous delicate flavored and colored products. The success of these products and the FDA approval in 1981 of new flexible container sterilization methods have stimulated interest in aseptic processing for a much wider range of products, utilizing different rigid and flexible containers.

Interest has been increasing for the availability of diced tomatoes to be used as a directly consumable item or as an ingredient for other formulated products. Some initial work at The Ohio State University Food Processing Pilot Plant, Columbus, in 1982 indicated acidified diced tomatoes can be presterilized and filled at 170° F or above in pouches and cans without further treatment.

This study is concerned with carrying this concept one step further. The specific objectives were to determine the process parameters, evaluate the effect of process variables on selected tomato cultivars, and determine the effect of process and flexible pouches on nutrient retention when diced tomatoes are aseptically processed and packaged.

MATERIALS AND METHODS

The initial work on this 3-year project was conducted during the 1983 processing season. Eight tomato cultivars (two runs of four cultivars each) were used as raw product. The tomatoes were grown at the OARDC Vegetable Crops Branch near Fremont and were a subsample of the raw product utilized in the Evaluation of Tomato Cultivars for Processing project at The Ohio State University Food Processing Pilot Plant. Raw product evaluation was conducted for each cultivar as described in OARDC Research Circular 271 (1).

Preprocessing preparation was the same for the two runs and eight cultivars. Tomatoes were washed and lye peeled using 18% caustic soda and 0.1% Faspeel at 190° F for approximately 90 seconds. After peeling, tomatoes were run over a rubber disc peel eliminator.

On the first run made August 31, after peel removal the tomatoes were diced on an Urschel model GK dicer set for ½ by ½ inch dices. The dices were collected in a hopper and pumped by a Warren Rupp Sandpiper 3-inch air-operated pump. Because of the lack of juice produced by dicing, pumping was difficult. For this reason, on the second run made Sept. 8, following peel removal tomatoes were chopped in a Fitzpatrick model D comminuting machine using a ½-inch screen. This procedure did not produce as uniform a dice, more of a ½-inch diameter chunk, but enough juice was produced to allow pumping with a vari-speed Moyno pump.

Following size reduction and pumping, the procedure on the two runs remained the same. The pumps propelled the tomatoes through a Speciality Brass Company ¾-inch diameter, 6-pass, 36-foot-long, stainless steel tube-in-tube heat exchanger. This unit was operated with a heating medium inlet temperature of 250° F and exit temperature of 245° F. Product entered the heat exchanger at approximately 90° F and was discharged at 210° F. Piping from the heat exchanger through the cooling heat exchanger to the aseptic filler was continuous 1½-inch sanitary pipe. A 22-foot section of this pipe was jacketed to provide a counterflow water cooler and 18 feet of air cooling before the filler. This cooling and piping arrangement produced product after filling of 125°-130° F. Retention time in the total 80-foot piping system from pump to filler was 2 minutes.

The filler used was a Liqui-Box Corporation model 1050-C2T-A aseptic dual-head bag filler. The filler was equipped with a product diversion valve and a self-contained high-pressure steam sterilization system.

Sterilization of the heat exchange and piping system was accomplished by pumping 200° F plus water through the units for a minimum of 30 minutes. A similar 30-minute high pressure steam sterilization, cycle was utilized for the filler.

This system of heat exchange, cooling and filling, equipment provided a sterilization and aseptic filling system of sufficient sterilization integrity for the pH levels of tomatoes.

The containers utilized for this study were laminated foil pouches, 12¼ inches by 15¼ inches, presterilized by gamma radiation, and provided by Liqui-Box. These pouches had the appropriate filling spout to operate with their filler. Properly filled pouches contained 8 to 8½ lb of product. Filling required the closed presterilized pouch to be placed in the filling heads by hand. The filler then retracted the filling spout into the filling area where sterilized air and chlorine mist maintained an aseptic filling atmosphere. The filler automatically removed the spout closure, metered in the diced tomatoes, and reclosed the spout. Filling was done continuously on alternate heads.

After filling, the pouches were given an additional cooling to 80° F in a cold water bath. This was necessary because of the short cooling section available.

As each cultivar was processed, approximately one-half was processed with no additive and the other half had the addition of one 3-gram salt and citric acid tablet per pound of product. These tablets were added after size reduction and prior to pumping.

After processing, the filled pouches were stored at 85° F. Sampling of the pouches is being done at 1, 3, and 6 months. During these samplings the product is being evaluated for color, pH, total acid, soluble solids, vitamin C, and product character.

[1]Assistant Professor and Professor, respectively, Dept. of Horticulture.

TABLE 1.—Average Evaluation Data for Aseptically Processed Tomato Dices.

Treatment	Percent S.S.	Vitamin C	Agtron E-5	Hunter a/b	Hunter TCM
1 month Storage					
No Salt or Acid	5.9	22.70	34.40	2.19	71.36
Salt and Acid Added	6.0	21.25	37.40	2.18	72.56
3 months Storage					
No Salt or Acid	5.7	18.33	35.68	2.15	71.77
Salt and Acid Added	5.8	15.88	39.16	2.18	74.77
Storage Period					
1 month Storage	5.95	21.98	35.90	2.19	71.93
3 months Storage	5.75	17.11	37.42	2.17	73.22
Treatments					
No Salt or Acid	5.8	20.52	35.04	2.17	71.55
Salt and Acid Added	5.9	18.57	38.28	2.18	73.66

RESULTS AND DISCUSSION

At this writing only samples stored for 1 and 3 months have been analyzed. Thus final results will have to wait until the 6-month storage period analysis. However, trends indicate the usefulness of this processing system.

Of the approximately 225 pouches produced, we have experienced 14 failures because of spoilage. Of these, 12 were from the first run first treatment where problems were experienced with pumping the dices with low liquid levels. This caused a lack of heat transfer in the heat exchanger and thus a lack of sterilization. The other two spoiled pouches were caused by improper filling cap reclosure caused by operator error.

The character of the dices was not as sharp or defined as hoped; however, we are sure the product damage was caused by the diversion valve utilized on the filler. In future processing this can be corrected.

A summary of the pertinent data obtained from 1- and 3-month sample periods is presented in Table 1.

The soluble solids data indicate close correlation between the salt and acid-treated and nontreated samples for the 1- and 3-month samples and also good correlation when comparing all of the treated samples with the untreated samples. There was a slight decrease in soluble solids when comparing the 1-month to the 3-month storage period. This is not significant and additional time is needed to see if this trend continues.

The vitamin C data indicate good retention during the first 3 months of storage. The only trend is a reduction in vitamin C when comparing the 3-month storage period to the 1-month period. The 22% reduction in vitamin C level is within accepted levels for the storage temperature and time conditions. If this level of reduction is maintained through the 6-month sampling period, it will indicate oxygen barrier protection is being given by the packaging material.

Color levels as determined by the Agtron E-5 readings and Hunter a/b ratio and TCM values all indicate good color retention. The small color differences are not significant. We will wait until the 6-month sample period to see if a different trend develops.

At this point the results look encouraging and we intend to follow this year's work with additional work next year. Our experience and data to date indicate the aseptic processing method of preservation can be utilized to produce a very acceptable diced tomato product.

REFERENCE

1. Food Processing and Technology 1982: A Summary of Research. The Ohio State Univ., Ohio Agri. Res. and Dev. Ctr., Res. Circ. 271.

The Addition of Sugar to Tomato Paste

W. D. BASH, J. P. DALMASSO, and W. A. GOULD[1]

INTRODUCTION

Tomato paste is the food prepared from the liquid obtained from mature red tomatoes and/or the liquid obtained from the residue of whole tomato canning, or the residue from partially extracted tomatoes. This liquid may have salt, spice, and flavoring added if declared on the label (1). However, since most paste is processed for use in other subsequent formulated food products, the condiments (other than maybe a small amount of salt) are not added. The liquid is concentrated to not less than 24% natural tomato soluble solids and processed by heat before or after sealing to prevent spoilage.

Because of the demand for tomato solids throughout the United States on a year-round basis, paste is produced in the tomato producing and processing areas during the growing season and shipped to the point of utilization as required. Even though it is not now covered by the standard of identity, there are times when the addition of sugar to paste might be cost effective. Many of the products produced from tomato paste require the addition of large quantities of sugar. Because of the different geographic areas of production, the different sugar pricing structures, or the availability of sugar, it may be more efficient to add the required sugar at the time of paste production rather than waiting until final product formulation.

The objective of this study was to determine the effect of sugar addition on the quality and usability of tomato paste at the time of manufacture.

MATERIALS AND METHODS

A 55-gallon drum of aseptically packaged tomato paste of 32% NTSS (natural tomato soluble solids) was obtained from Agroex Del Peru, SA. A 200-lb sample of granular cane sugar was obtained from the same supplier. All samples were prepared from the same lot of paste and sugar during one processing session to eliminate raw product and time variables.

At the time of opening the drum of tomato paste, six probe samples of paste were taken to determine if there was any variability of product within the drum.

The sugar was added to the paste as dry granular sugar and as a 65° Brix syrup. The samples with dry sugar were made by adding paste and sugar on a weight basis to obtain 10%, 20%, 30%, and 40% sugar mixtures. The sugar and paste were thoroughly mixed prior to processing. Samples for analysis were taken after mixing and after processing.

Samples made with syrup were made by first mixing a single batch of 65° Brix syrup. The paste and syrup were then blended on a weight basis to obtain 10%, 20%, 30%, 40%, and 50% syrup mixtures. These syrup concentrations corresponded to 6.5%, 13.0%, 19.5%, 26.0%, and 32.5% sugar on a dry basis. Again, samples were taken after mixing and after processing.

Processing was accomplished by pumping the mixed samples through the 6-pass, 36-foot, ¾-inch, stainless steel tube-in-tube heat exchanger. The heat exchanger was operated with a heating media inlet temperature of 255° F and exit temperature of 250° F. The product initial temperature was 75° F and the temperature obtained after process was 160° F. Samples were taken immediately after the heat exchanger and the remainder of the product hot filled into 303 x 406 cans, sealed, and cooled for further reference.

Samples taken from the drum of paste and from the test samples before and after processing were all evaluated using the same tests and procedures.

The following tests and procedures were utilized:

- **pH:** The pH was determined by the glass electrode method using 10 g of product diluted with 90 g of distilled water (3).
- **Percent total acid as citric:** The sample used for pH determination was directly titrated using 0.1 normal sodium hydroxide solution to a pH of 8.1 (3).
- **Percent natural tomato soluble solids:** A 100 g sample was diluted with 100 g distilled water and filtered. An Abbe refractometer was used to determine the refractive index of the filtrate. These readings were corrected for dilution, temperature, and insoluble solids per USDA procedures (2) to give percent NTSS.
- **Consistency:** All samples were diluted back to 12% NTSS with distilled water and evaluated using the Bostwick consistometer per USDA procedures (2).

RESULTS AND DISCUSSION

The data obtained during this study are presented in Table 1. The data indicate that pH of tomato paste is affected very little by the addition of sugar. However, total acid is reduced significantly as the amount of sugar is increased. Also, this reduction in total acid is more pronounced when the sugar is added as a syrup. This is true even when the amount of actual sugar is the same. Processing seems to have very little effect on either pH or total acid.

The effect of sugar addition on the percent NTSS is predictable. As the amount of sugar is increased, the percent NTSS also increases. Of course, in those cases where the actual sugar content (20% dry-30% syrup and 30% dry-50% syrup) is almost equal, the percent NTSS is much higher for the dry sugar samples because of the diluting effect of the water in the syrup.

The effect of sugar levels on Bostwick consistometer readings is quite pronounced. As the amount of sugar is increased, the Bostwick is reduced. It must be remembered that all samples were reduced to an NTSS level of 12% prior to testing according to the USDA procedures.

[1]Assistant Professor, Instructor, and Professor, respectively, Dept. of Horticulture.

TABLE 1.—Effects of Addition of Sugar to Tomato Paste.

	pH	Total Acid	Percent NTSS	Bostwick	L	a	b	a/b	TCM	Agtron E-5
Plain Tomato Paste	4.32	1.99	32.0	7.1	24.16	24.99	12.62	1.98	73.62	51.2
Percent Dry Sugar Unprocessed										
10	4.32	1.78	39.9		23.00	24.70	12.18	2.03	77.83	52.0
20	4.32	1.59	46.2		21.60	24.55	11.65	2.11	83.52	52.5
30	4.35	1.23	54.7		20.40	23.95	11.10	2.16	88.84	51.5
40	4.38	1.06	60.1		19.28	24.01	10.62	2.26	94.83	48.0
Percent 65° Brix Syrup Unprocessed										
10	4.35	1.65	34.4		23.89	25.56	12.72	2.01	74.79	48.0
20	4.32	1.52	37.7		22.75	25.02	12.13	2.06	78.96	50.0
30	4.32	1.38	40.1		22.07	24.85	11.87	2.09	81.64	46.0
40	4.31	1.15	43.9		21.06	24.49	11.35	2.16	86.06	45.0
50	4.30	0.91	46.6		19.87	23.84	10.80	2.21	91.61	43.0
Percent Dry Sugar Processed										
10	4.33	1.63	40.3	10.25	22.64	24.38	12.18	2.00	78.86	52.0
20	4.31	1.47	46.8	13.00	22.32	24.76	12.04	2.06	80.43	50.5
30	4.37	1.33	54.5	27.00	20.42	23.95	11.16	2.15	88.66	51.5
40	4.34	1.13	60.1	27.00	19.51	23.95	10.74	2.20	93.21	48.0
Percent 65° Brix Sugar Processed										
10	4.31	1.51	36.1	8.50	23.75	25.61	12.84	1.99	75.11	49.0
20	4.34	1.51	37.9	9.25	22.87	24.99	12.26	2.04	78.36	46.5
30	4.31	1.38	40.7	12.25	21.86	24.92	11.93	2.09	82.39	44.0
40	4.32	1.23	44.5	15.00	21.04	24.64	11.63	2.12	85.84	46.0
50	4.31	0.95	47.0	27.00	19.89	24.03	11.07	2.17	91.23	44.0

Thus, considerably more water had to be added to the higher sugar level samples and in turn there was a reduction in total solids. Samples of both dry sugar and syrup where the percent NTSS was above 30% gave readings greater than 27, which is the machine maximum measuring capability. It should be noted that the consistency of the paste and dry sugar mixture decreased as the sugar increased up to the maximum 40% level. Of course, the change in consistency when syrup was added was more drastic due to the added dilution caused by the water in the syrup.

The color change can be noted in both the Hunter and Agtron readings. As the sugar level increased, the color decreased from the dark red paste color to a lighter, brighter red. There is a slight indication of darkening in color caused by processing. This change would be expected and in fact may have been retarded by the addition of the sugar.

In conclusion, there does not appear to be any reduction in quality of tomato paste when sugar is added. final product would have to be taken into consideration so as not increase the sugar content above that required.

It should be pointed out that the sugar should be added prior to the processing operation because of the possible microbiological contamination that may be present in sugar.

REFERENCES

1. Food and Drug Standards of Identity, Quality, and Fill. U. S. Food and Drug Administration, Washington, D. C.
2. Methods of Analyses for Tomato Products, Solids Content Determinations. U. S. Dept. of Agriculture, Consumer and Marketing Service, Fruit and Vegetable Division, Processed Products Standardization and Inspection Branch.
3. Gould, W. A., 1977. Food Quality Assurance. AVI Publishing Co., Westport, Conn.

This page intentionally blank.

The Ohio State University
Ohio Agricultural Research and Development Center